VISCO STEELSHELL Water Coolers

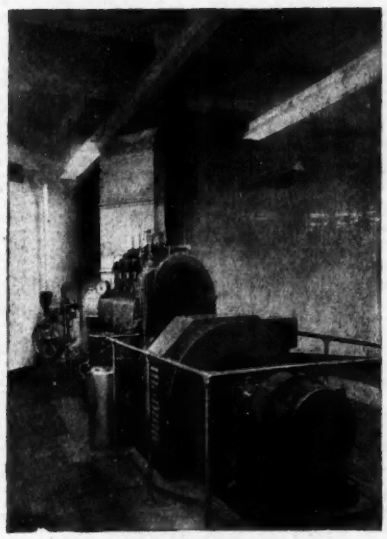
ou use Mains water for cooling a diesel, compressor, gerating plant, etc., you can cut down your water con-ption about 97% by installing a "Visco" Steelshell er Cooler. With this unit, the cooling water is recircu-l continuously. There is no waste as when Mains r is used once only, and run to waste.

n space at ground level is not available, this cooler be placed on the roof. Or it can be mounted on a frame well above the ground and the space beneath for dumping fuel or other purpose.

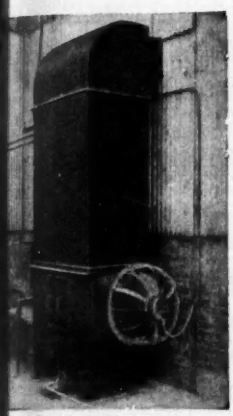
sco" Steelshell Units are used extensively in air con-ning and for cooling diesels, air compressors, refri-ting and ice cream machinery, cardboard machines etc.

●

We have all sizes. Ask for List No. 514.



—"Visco" Steelshell Unit cooling ish Polar engine in Cigarette Paper tory.

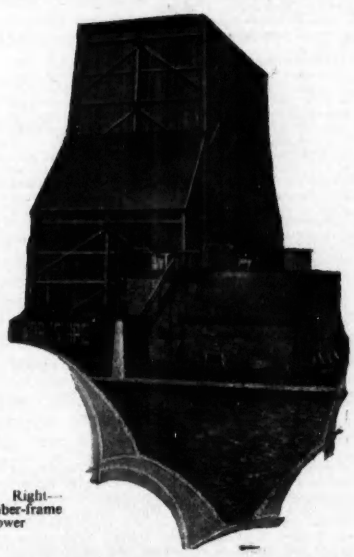


—"Visco" Steelshell Cooler, 1,000 gal. per hour size, in a Printing Works.

VEC

LARGE SCALE ATER COOLING

Power Stations and Industrial where a large volume of water o be cooled we supply and erect -framed or ferro-concrete towers al or forced draught) of any ity required up to one million s of water per hour. See ated List No. 524.



Right—
150,000 gals. per hour timber-frame "Visco" Cooling Tower

: Croydon 4181/4

CO ENGINEERING CO. LTD. STAFFORD RD. CROYDON

ALSO MAKERS OF AIR FILTERS, DUST COLLECTORS & FUME REMOVAL PLANT

THE ENGINEER

ESTABLISHED 1856

Vol. 198 No. 5139

JULY 23, 1954

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

SUBSCRIPTIONS

U.K. & ABROAD £5. 10. 0. CANADA £5. 5. 0. annually including postage. Every subscriber is entitled to one FREE copy of the BUYERS GUIDE as published —extra copies 5s. each post free.

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LINEAGE RATE (Under 1 inch):—2s. 6d. per line of 6 words. Minimum 10s.

INCH RATE (1 inch and over):—Rates per insertion per single column inch— 1 insertion—30s. 6 insertions—27s. 6d. 13 insertions—26s. 26 insertions—25s.

USE OF BOX NUMBER: The charge is 2s. including the cost of re-addressing replies, which are forwarded immediately on receipt. N.B. There is no Charge for Box Nos. under "Situations Wanted."

WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF ADELAIDE

SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for appointment as SENIOR LECTURER IN MECHANICAL ENGINEERING.

A candidate should be able to lecture on the application of mechanics to machine design, and should be familiar with the economics and procedures of current engineering design. The successful candidate will be required to lecture to third and fourth-year students and to supervise drawing-office design projects.

Terms: every potential applicant is invited to seek from the undersigned or from the Secretary of the Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1, a copy of the detailed conditions of appointment.

Salary scale : £A1360–£A60–£A1600.

Superannuation : on F.S.S.U. basis.

Application : an application must include particulars of age, nationality, academic record, teaching qualifications, war service (if any), and present position ; a list of publications ; copies of testimonials ; the names and addresses of two referees of whom inquiries may be made ; a recent photograph ; and a medical certificate of good health. It should be lodged in duplicate with the undersigned not later than September 15th, 1954.

Further information about the particular post or about the University will be supplied on request to :

A. W. BAMPTON,
Registrar.

University of Adelaide,
Adelaide, South Australia. E9745

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURER

Applications are invited for the post of LECTURER in the Department of Mechanical Engineering. Preference will be given to candidates with special interests in strength of materials. Salary within the range £550–£1100 per annum, according to qualifications and experience.

Applications, stating age, qualifications and experience, together with the names of three referees, should be received not later than 21st August, 1954, by the undersigned, from whom further particulars may be obtained.

STANLEY DUMBELL,
Registrar.

E9727

DERBY EDUCATION COMMITTEE

DERBY TECHNICAL COLLEGE

Principal : T. HEAP, Ph.D., M.Sc., F.R.I.C.

ASSISTANT, GRADE A

Applications are invited for the post of ASSISTANT, Grade A, in the Mechanical Engineering Department, with special reference to workshop technology or other trade course, duties to commence on 1st September, 1954. Candidates should be Graduates or holders of City and Guilds Full Technological Certificates, or possess equivalent professional qualifications and have had industrial experience. Salary in accordance with the Burnham Scale for Assistants, Grade A, £415–£18–£670, with allowances for Degree and training and up to twelve increments for industrial experience. Application forms and details of the post may be obtained from the Principal, Derby Technical College, Normanton Road, Derby, by whom completed applications should be received within two weeks of the appearance of this advertisement.

C. MIDDLETON,
Director of Education.

Education Office,
Becket Street, Derby. E9754

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for a post as LECTURER IN MECHANICAL ENGINEERING. Duties will commence as soon as possible.

Candidates should hold a good Honours Degree in Mechanical Engineering and have practical experience in industry and in teaching. Salary in accordance with the Burnham Technical Scale for Assistants, Grade A or B, according to qualifications and experience.

Further particulars and application form will be sent by the undersigned on receipt of a stamped addressed foolscap envelope. Applications should be sent in to reach the undersigned not later than Monday, 16th August, 1954. Applications not on the form provided will be disregarded.

E. C. SMITH,
Principal.

12th July, 1954. E9715

EAST HAM COUNTY BOROUGH

EAST HAM TECHNICAL COLLEGE

ASSISTANT, GRADE A

Required, September, 1954, ASSISTANT, Grade A, for mechanical engineering subjects (including engineering science, drawing and mathematics) for National Certificate, City and Guilds and Preliminary Courses.

Burnham Technical Scale (London area).

Applications to be submitted immediately to Chief Education Officer, Town Hall Annexe, Barking Road, London, E.6. E9768

ROYAL TECHNICAL COLLEGE, SALFORD

Principal : P. F. R. VENABLES, Ph.D., B.Sc., F.R.I.C.

MECHANICAL ENGINEERING DEPARTMENT

ASSISTANT, GRADE B

Applications are invited for the post of ASSISTANT, Grade B, in the Mechanical Engineering Department. Salary will be in accordance with the Burnham Technical Scale, 1951, plus graduate and training allowances.

Applicants should hold an Engineering Degree and/or professional qualifications and have had good industrial experience.

The successful candidate will be required to teach general mechanical engineering subjects to Ordinary National Certificate standard, and to offer specialised subjects to College Associateship and Higher National Diploma and Certificate standard in either Aeronautical Engineering or Production Engineering.

Forms of application and further particulars may be obtained from the Principal, Royal Technical College, Salford, 5, to whom they should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
Clerk to the Governors.

E9729

WEST RIDING COUNTY COUNCIL

PUDSEY TECHNICAL INSTITUTE
NR. LEEDS

ASSISTANT, GRADE A

ASSISTANT, Grade A, required to teach in Part-Time Day and Evening Courses in Engineering to City and Guilds Intermediate Standard (Machine Shop Engineering). This post offers an opportunity to develop experimental work with the craft apprentice.

Qualification : Final City and Guilds in Machine Shop Engineering, or a qualification in Production Engineering, together with good practical experience in engineering trades.

Main subjects : calculations and science, workshop technology and practice ; ability to take some English and an interest in the development of social life of the Institute would be added recommendations.

Salary will be in accordance with the appropriate Burnham Technical Scale.

Application forms may be obtained from Mr. H. Flather, Divisional Education Officer, Pudsey, Nr. Leeds, to whom completed applications should be returned within 14 days of the date of the appearance of this advertisement. E9775

SURREY EDUCATION COMMITTEE

REDHILL TECHNICAL COLLEGE,
REDSTONE HILL,
REDHILL

ASSISTANT GRADE A

Required, September, full-time ASSISTANT, Grade A, to teach mathematics and electrical subjects, Graduate preferred. Salary Burnham Technical Scale (men), £415 by £18 to £670 p.a. Forms of application obtainable from the Principal, to whom they should be returned as soon as possible.

E9769

THE INSTITUTE OF BRITISH FOUNDRYMEN

SECRETARIAL STAFF

Applications are invited from men of good organising ability, preferably between 30 and 40, for a vacancy on the SECRETARIAL STAFF of the Institute of British Foundrymen. Duties include secretarial work for technical committees and technical editorial work. Considerable travelling involved. Verbatim technical reporting and editorial experience would be particularly useful. Exacting standard of work required, but remuneration good with excellent pension scheme.—Particulars of age, education, experience and salary required, should be sent to the Secretary, St. John Street Chambers, Deansgate, Manchester, 3. E4368

ASSISTANT ENGINEER (MECHANICAL)

OVERSEA GOVERNMENTS AND ADMINISTRATIONS

ASSISTANT ENGINEER (MECHANICAL) required for their London office by the Crown Agents for Oversea Governments and Administrations. Basic salary scale £650 by £25 to £750 by £30 to £960 by £40 to £1000 a year, plus extra duty allowance of approximately 8 per cent. The £650 minimum is linked to entry at age 25 and is subject to increase at the rate of one increment for each year above that age up to 34. Fully qualified officers at least 27 years old may be eligible for a special increase of £75 after two years' service. Engagement is on unestablished terms with prospect of appointment to the established staff and of promotion. Candidates between 25 and 35 years of age should have passed the qualifying examination for Associate Membership of the Institution of Mechanical Engineers or equivalent examination. They should have served an apprenticeship or pupilage in the Locomotive or Rolling Stock Department of British Railways or with a firm of locomotive or rolling stock builders, or with a firm specialising in the manufacture of wharf or breakdown cranes. They should also have subsequent drawing-office experience in the design of locomotives or carriages and wagons and diesel railcars or cranes, together with a normal knowledge of modern workshop practice.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2A/30691/EH. E9706

CITY OF GEORGETOWN

BRITISH GUIANA

APPOINTMENT OF ASSISTANT ENGINEER

1. Applications for the above-mentioned post in the City Engineer's Department are invited by the Mayor and Town Council of Georgetown, British Guiana. The salary of the office is £900 a year, rising by annual increments of £50 to £1000 a year, plus a cost-of-living allowance at the present rate in force. A motor-car allowance at the rate of £125 a year will be paid.

2. Applicants (who must be under 40 years of age at the closing date for applications) must have had good training and practical experience in general civil engineering work, in setting out and supervision of constructional and maintenance work, and in handling labour. They must be good draughtsmen and competent to make surveys, take levels and prepare plans, specifications, quantities and estimates for general municipal engineering work.

3. Possession of one or more of the following qualifications will be an advantage :—

(1) Degree in Civil Engineering of a University in the British Commonwealth.

(2) Final Parts I and II of the A.M.I.C.E. Examination.

(3) Final Examination, Institution of Structural Engineers.

(4) Testamur Examination, Institution of Municipal Engineers.

4. Preference will be given to University Graduates with at least seven years' municipal experience.

5. Applicants must state age, present appointment, qualifications and experience, and submit copies of not more than four recent testimonials.

6. Term of engagement is for three years, commencing from the date of arrival at Georgetown, British Guiana, with possible re-engagement for a further period on such terms as may be mutually agreed. Half salary will be paid from the date of embarkation of first engagement. Full salary will begin from the date of arrival at Georgetown, British Guiana.

7. The holder of the appointment will be required to devote the whole of his time to the duties of his office and to reside in the City of Georgetown.

8. The selected applicant will be required to pass satisfactorily a medical examination before appointment.

9. The appointee will be eligible on termination of first engagement for four and a half months' vacation leave at full salary at the rate then being paid, but if he is subsequently re-engaged on a permanent basis, will be eligible, under the Council's Leave Regulations, for six months' leave after four years of service.

10. Applications from the United Kingdom should be addressed to the Council's Agents, Messrs. James J. Sabey and Son, Ltd., 190, Bishopsgate, London, E.C.2, and must reach them not later than the 29th July, 1954.

11. Applications from British Guiana and the West Indies should be addressed to the Town Clerk, Georgetown, British Guiana, and must reach him not later than the 29th July, 1954.

Copies of the form of agreement to be entered into between the Council and the selected applicant can be obtained on request from the Town Clerk, Georgetown, or the office of the Council's Agents.

E. A. ADAMS,
Town Clerk.

The Town Hall,
Georgetown,
British Guiana. E9686

HER MAJESTY'S COLONIAL SERVICE

WORKS AND HYDRAULICS DEPARTMENT, TRINIDAD

SANITATION ENGINEER

Applications are invited for the following post :—SANITATION ENGINEER, Works and Hydraulics Department, Trinidad.

Duties include design and organisation for improvement of land drainage, river clearing and swamp drainage.

Appointment on contract for three years in first instance. Salary according to qualifications and experience in incremental scale £1000–£1200 per annum, plus gratuity payable on satisfactory completion of contract at rate of £37 10s. for each completed period of three months' service; £60 outfit allowance; free passages ; limited free medical attention.

Candidates, who should not be over 35, must hold a University Degree or Diploma recognised as exempting from, or have passed, the Final Parts I and II of the A.M.I.C.E. Examination, plus at least seven years' practical experience in civil engineering works.

Full details on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number BCD/112/38/010/D4.

E9707

ST. PANCRAS BOROUGH COUNCIL

BOROUGH ENGINEER AND SURVEYOR'S DEPARTMENT

TECHNICAL ASSISTANT

TECHNICAL ASSISTANT required on permanent establishment of Borough Engineer and Surveyor's Department, A.P.T. III–IV (£550–£625) : commencing salary £550, plus London weighting allowance according to age. Duties include preparation of drawings, specifications, &c., and supervision of building and engineering works. Applications, giving full details of experience and qualifications, with names of three referees, to reach undersigned by 20th August. No housing. State whether related to any member or senior officer of Council.

R. C. E. AUSTIN,
Town Clerk.

St. Pancras Town Hall,
Euston Road, N.W.1. E9719

THE LEE CONSERVANCY CATCHMENT BOARD

CIVIL ENGINEERING ASSISTAN

Applications are invited for the above appo within the range of Grades A.P.T. I–Va (sala to £715 p.a., plus London weighting), acco experience and qualifications.

The appointment is in connection with scheme of works which is expected to conti several years. The works include heavy exc bridges, mass, reinforced and prestressed c culverts, sewers and ancillary works. A should be neat and expeditious draughtsm surveyors with some experience of design supervision of works of some magnitude.

Travelling and subsistence allowances from time to time will be payable, and the s candidate may be required to provide his ow

The appointment will be subject to the Scheme of Conditions of Service for Local rities' Administrative, &c., Staffs, and to one notice on either side, and the successful may be required to pass a medical exam Applicants should state whether they would be specified as contributory employees for poses of the Local Government Superannua 1937, and, if so, give particulars of previo tributory and non-contributory service.

Applications, stating age, qualifications ence, &c., accompanied by copies of thr testimonials, and endorsed "Civil Eng Assistant," should reach N. Medrington A.M.I.C.E., M.I.W.E., Engineer to the Board Grange," Crossbrook Street, Cheshunt, He later than first post on Monday, 16th August

J. L. SPILLER,
Clerk of the B

Head Office of the Board :
Brettenham House,
Lancaster Place,
Strand, London, W.C.2.

MINISTRY OF WORKS

ENGINEERING DRAUGHTSME

ENGINEERING DRAUGHTSMEN req London, Edinburgh, Glasgow and various p offices.

Candidates must have British nationality, standard of Ordinary National Certificate valent, and apprenticeship or practical exper at least three years, including one in a drawin in one of the following categories :—

Mechanical : Plant layout, boilers an distribution, pumps, rotating machinery, h light mechanisms, servo systems and pressure

Electrical : Lighting and power insta overhead and underground distribution syst all types of equipment, instrumentation and c

Heating and Ventilating : All types of and/or ventilating systems, refrigeration conditioning.

London salaries (men), £420 (at age 21) p.a. Starting pay according to age and exp Rates elsewhere slightly less. Prospects of pro and permanency.

State age and full details of training and ex to W.G. 10/C.E. 10 (I), Ministry of Work House, John Islip Street, London, S.W.1.

COUNTY BOROUGH OF EAST

APPOINTMENTS

ENGINEERING ASSISTANT, Grade A £620–£670.

QUANTITY SURVEYOR, Grade A.P. £580–£625.

SENIOR ARCHITECTURAL ASSIS Grade A.P.T. VI, £695–£760.

ARCHITECTURAL ASSISTANT, Grade V, £620–£670.

London weighting is paid in addition. S excess of the minima may be paid accord qualifications and experience.

Subsistence allowances may be granted reasonable period to persons appointed if un obtain suitable housing accommodation, neces the maintenance of two homes.

Further details and application forms, ret by 6th August, 1954, from the Town Clerk Hall, East Ham, E.6.

BRITISH ELECTRICITY AUTHO

RESEARCH LABORATORIES, LEATHERHEAD

GENERAL ASSISTANT ENGINE

British Electricity Authority Research Labor Leatherhead, require a GENERAL ASSIS ENGINEER with a University Degree in El or Mechanical Engineering or in Physics. include testing, development and research the laboratories and in the field in connectio the generation, transmission and distribu electricity. Salary N.J.B. Grade 5, £531– Forms from D. Moffat, Director of Establis Winsley Street, London, W.1, to be retur August 7th. Quote reference ENG/481.

LONDON COUNTY COUN

CIVIL ENGINEERS, CIVIL ENGINE ASSISTANTS AND DRAWING O STAFF

CIVIL ENGINEERS, CIVIL ENGINEE ASSISTANTS and DRAWING OFFICE S for design of large civil engineering works in c tion with main drainage and sewage purifi Applications form from Chief Engineer London County Council, County Hall, returnable within next 14 days. (Enclose (727).

THE ENGINEER

JULY 23, 1954

Council of the Institution of Electrical Engineers, 1954–55

THE Institution of Electrical Engineers has announced the constitution of its council for the session 1954–55. The president will be Mr. J. Eccles, C.B.E., who, it may be recalled, succeeded Sir John Hacking as deputy chairman (operations) of the British Electricity Authority after Sir John's retirement last December. Mr. Eccles, who has a long association with the electricity supply industry, was the president of the Incorporated Municipal Electrical Association when it held its final convention at Eastbourne in 1948 before being succeeded by the British Electrical Power Convention. When the electricity supply industry was nationalised Mr. Eccles was appointed chairman of the Merseyside and North Wales Electricity Board. The two vacancies as vice-presidents of the Institution of Electrical Engineers will be filled by Dr. Willis Jackson and Sir Gordon Radley, and the honorary treasurer will be Mr. H. W. Grimmitt. There were six nominations for five members to be ordinary members of the council and as the result of a ballot the five vacancies will be filled by Mr. A. R. Cooper, Mr. F. J. Lane, Sir Hamish D. MacLaren, Mr. W. F. Parker and Mr. E. L. E. Wheatcroft. Mr. J. H. Westcott will join the council as an associate member, and, as the result of a ballot, Mr. J. Bennett will fill the vacancy for an associate, for which there were three nominations. It is announced that the council has co-opted Mr. B. Donkin, M.I.E.E., to fill the casual vacancy created by the election of Dr. Willis Jackson as a vice-president before the completion of his term of office as an ordinary member of council.

Lloyd's Register Shipbuilding Returns

THE shipbuilding returns for the quarter ended June 30, 1954, have been published by Lloyds' Register of Shipping. In Great Britain and Northern Ireland, the steamships and motorships under construction amounted to 328 ships of 2,195,085 tons gross, and of this total 89 ships of 573,834 tons were completing afloat and 239 ships of 1,621,251 tons were still to be launched. During the quarter 66 ships of 356,442 tons were commenced and 63 ships, representing 350,340 tons, were launched, while those completed totalled 60 ships of 345,872 tons. For registration abroad 100 ships of 726,185 tons were under construction, representing 33·1 per cent of the total being built and an increase of 126,264 tons over the previous quarter. The total of the volume of orders outstanding fell by 236,190 tons during the first quarter of the year, and by 230,605 tons in the second quarter, and the ships for which plans have been approved or material ordered amounted to 244 of 1,691,035 tons, the proportion of oil tankers being 55·8 per cent. Work in hand abroad, excluding China, Poland and Russia, totalled 764 ships of 3,653,806 tons, and represented a decrease of 337,436 tons compared with the end of March. A total of 204 ships of 723,881 tons were commenced during the quarter, 259 ships of 1,210,245 tons were launched, and the total completed was 251 ships, representing 1,066,641 tons. In the world 1092 steamships and motorships of 5,848,891 tons were under construction, of which 37·5 per cent were building in Great Britain and Northern Ireland. Oil tankers under construction amounted to 284 ships of 3,353,522 tons, including 128 steamships of 2,008,764 tons and 156 motorships of 1,344,758 tons. Of the 2,121,336 tons under construction for countries other than the country of building, 34·2 per cent was building in Great Britain and Northern Ireland. At the end of June, 3,845,766 tons, or 65·8 per cent, of the ships under construction throughout the world were being built under the inspection of Lloyd's Register.

British Welding Research Association

THE British Welding Research Association's annual luncheon was held at Abington, near Cambridge, on July 14th. Proposing the toast of "The Association," Dr. O. H. Wansbrough Jones, Chief Scientist, Ministry of Supply, stressed the importance to industry of co-operative research. Replying, Sir Charles Lillicrap, chairman of the Association's council, gave examples of successes due to the work of the Association. He said that an improved welding procedure had resulted in a 50 per cent saving in the cost of £1,000,000 contracts of welded gas pipes. The plastic design of welded steel frames had over the last year saved £250,000. There was no shortage of problems for investigation and there were thirty to forty projects which could be started at once if funds could be made available. In view of the prospect of the D.S.I.R. grant to the Association being reduced in 1956 from 100 per cent to 70 per cent of the contribution from industry, an increase of 25 per cent in that contribution was being sought. That, Sir Charles felt, was a very small sum compared with the results that were being achieved. After the luncheon the laboratories were open to inspection and the equipment was demonstrated by the staff. The researches cover such problems as fatigue failure of pipes, pressure vessels, plates and thin gauge box sections and the strength of full-scale steel frames designed by Professor Baker on plastic theory; the strength of reinforced openings in storage tanks, resistance welding (including a recently installed three phase frequency changer spot welding machine of American design); non-destructive testing, the brittle fracture of plates and oxygen cutting. A display gave a survey of the work of the metallurgical laboratory. This is at present housed at the Association's London headquarters, but its early transfer to Abington is being planned.

Towns' Wastes in Agriculture

THERE has just been published by H.M. Stationery Office a report by the National Resources (Technical) Committee entitled "The Use of Towns' Wastes in Agriculture." The conclusions drawn are as follows: The quantities of nutrients and humus-producing materials which would be made available by the full agricultural utilisation of our towns' wastes are small compared with those applied each year as fertiliser and contributed by normal farming practice. Apart from dried digested sludge and activated sludge the potentialities of towns' wastes in agriculture have often been overestimated. Nevertheless, minor scale developments in the preparation of composts of sewage sludge and agricultural wastes, by local authorities and farmers in collaboration, are justified where local conditions are favourable. In horticulture, where there is often a need for the application of bulky organic matter, compost made from towns' wastes has value. Composting of household refuse and liquid sewage sludge by local authorities appears to be generally uneconomic. The committee is therefore of the opinion that there is no case for authorising the expenditure of public money on pilot plant experiments on methods of composting. It would, however, be valuable to have further information about the costs of production in a fully mechanised plant. Such information may become available from the new plant to be set up at St. Helier, Jersey. Three-quarters of the nitrogen in sewage, about 60,000 tons, is lost to sea in the effluent. Attention should be given to the investigation of methods of sewage treatment whereby part of this nitrogen might be recovered. An estimate of the cost of nitrogen recovery from sewage compared with that of producing nitrogenous fertilisers by conventional methods would be useful. The manurial value of screened dust is low and large quantities must be applied to get a significant response on crops. Its use for agriculture is therefore uneconomic owing to transport costs and cost of application.

Building Research in 1953

THE reports of the Building Research Board and the Director of Building Research of the D.S.I.R. for 1953 have now been published. Much interesting information, gained by the Building Research Station during the course of its work, is presented in the director's report. The station advises on all building materials except wood (with which the Forest Products Research Laboratory deals), and a lengthy section of the report recounts the year's studies with numerous materials, including, for example, researches on the frost resistance of building stone, which at present appear somewhat inconsistent, and a note on the manufacture of bricks from pulverised fuel ash and clay. The latter work is well advanced and is being applied on a full scale by the British Electricity Authority. The efficiency and productivity of building operations and methods are considered in one section of the report—tower cranes, mechanical aids and new kinds of building components are discussed—and building services are discussed in a later section. The engineering aspects of the station's work include soil mechanics, in which a great effort was made in 1953 in studying the mechanisms of failure of earthen banks on the East Coast, and their reconstruction after the floods of February of that year. A number of valuable investigations in the design and performance of structures were also in progress. They included impact and fire-resistance tests of prestressed concrete beams, experimental full-scale tests of a concrete shell roof, and laboratory tests on unreinforced concrete walls. Further study was made of the behaviour of rigid steel frames in multi-storey buildings, principally to achieve economy of steel and a simple design method for such frames. Measurements of stresses in the steel frame of the new Government offices in Whitehall Gardens formed part of the researches into steel-framed buildings.

Commonwealth Industrial Welfare Conference

THE Industrial Welfare Society is making plans for a Commonwealth and Empire conference on "The Social Responsibility of Industry," which will be held in this country, probably at Oxford, in July, 1956. H.R.H. The Duke of Edinburgh, who is patron of the Society, is particularly interested in this conference and, last Monday, presided over a meeting at Buckingham Palace of industrialists and trade unionists to discuss it. After the meeting, the Industrial Welfare Society stated that the purpose of the conference would be to bring together representatives from the Commonwealth and Empire who would pool their knowledge and experience of the human problems of industry in their own countries. It was intended, the Society said, that the age of the delegates should normally be between twenty-five and forty. The Society explained that the conference would deal with the human factors of industry as a whole, considering, on the one hand, the personal factors of the health, satisfaction, effectiveness and well-being of those working in industry and, on the other hand, the social problems arising from the effects of industrialisation on the lives of individuals, their families, and communities. There was no suggestion, the Society's statement added, that the conference should discuss formal relationships between employers and trade unions covering wages, conciliation and arbitration machinery.

Some Notes on the Development of Fairground Machinery

By P. W. BRADLEY

No. II—(*Continued from page 95, July 16th*)

The evolution of the ordinary roundabout is traced, with particular reference to the development of a satisfactory galloping action for the wooden horses. Machines in which a fixed axis supports the whole revolving mass are dealt with in particular.

THE first class of amusement device to be considered is that which, for want of a better term, can be called the "ordinary roundabout." This can be more precisely defined as a circular riding machine in which virtually the whole structure revolves about a vertical axis, its weight being borne solely by the fixed centre. Mr. Thomas Murphy's paper, "The Evolution of Amusement Machines," quotes from various early writings which establish that hand-propelled roundabouts, large enough to carry adults, existed in this country before 1800. The next step was the introduction of animal power. Mr. Murphy describes a typical roundabout of that era as consisting of a vertical centre pole supporting a bearing for a revolving wheel from the spokes of which were suspended eight pairs of wooden horses and two ornate carriages to carry six people each. Motive power was supplied by a pony harnessed to the inner side of one of the carriages. At the time the paper was presented (March, 1951) one of these machines was stated still to be touring in the West of England.

Steam power, according to Mr. Murphy, was first tried in about 1865 by a Mr. Soames, of Marsham, Norfolk, who employed a small stationary engine and a flat belt drive to operate a roundabout. This arrangement, the paper tells us, did not prove satisfactory, and the project was abandoned. Frederick Savage, engineer, of King's Lynn, later entered the field and his firm became the leading manufacturers of portable riding machines, a position it retained for many years. There can be little doubt that the first practical steam-driven ride was devised and built by Mr. Savage and amounted to a powered version of the pony roundabout already described.

"Steam Dobby Horses" (later known as "Still Horses" or "Swing-Out Horses," to distinguish them from "gallopers" when these appeared) had as centre piece a four-wheeled truck which could be drawn by horses on the road. The "centre pole" (actually a hollow column) was a permanency on this vehicle, and arrangements were made for it and its struts to be extended downward, to be supported by jacks from the ground. As can be seen in the drawing, Fig. 3, the two-cylinder horizontal steam engine was mounted on a locomotive-type boiler, arranged across the rear of the truck, and it drove through spur and bevel gearing a vertical countershaft. A pinion on the upper end of this shaft engaged internally a bar-toothed gear on the underside of the revolving top frame, which consisted of a series of radial beams, known as "swifts," inserted into slots in the "cheesewheel," which revolved about the "pole." The swifts were spaced apart radially by one or more circles of spacers, called "quarterings." The pole had an upward extension (which could be lowered on a hinge into a horizontal position for travelling) at the top of which a roller race carried anchorages for a series of inclined iron tie rods which relieved the swifts of bending stress and transmitted most of the weight of the horses and riders directly to the centre pole. The wooden horses, arranged either two or three abreast, were suspended from the swifts by means of single vertical rods passed through their bodies, and having hooked upper ends which entered eye bolts in the swifts. An inward protrusion from the horse rod, near its upper end, engaged in a slotted bracket (or elongated eye bolt) fastened to the underside of the swift, inboard of the first eye bolt. This device prevented twisting of the horse rod, limited the extent of swinging out under the action of centrifugal force, and prevented the inward swinging which otherwise would have made the horse difficult to mount. Carriages were often incorporated in the design, as on the earlier pony machines, and old photographs indicate that they were sometimes roofed, and quite roomy. Horses, however, appeared to be smaller than those on later (galloping) roundabouts. A mechanical organ, also small by later standards, was usually placed inside the machine alongside the centre truck, and driven by belt from a small single-cylinder, vertical engine steamed from the main boiler.

Later "steam dobbies" had a circular platform, with a single continuous step, suspended from the quarterings of the top frame by rods. For ease of transport the platform was made segmental, in as many sections as there were swifts. Besides making mounting easier, the platform improved the appearance of the machine, and it enabled fares to be collected while the ride was in progress. In these early stages of development, it became customary to build roundabouts to run clockwise, presumably so that horses were mounted from the correct side, and in English-built circular riding devices that convention still persists. Steam dobby horses were once quite numerous, and several sets travelled regularly until long after the introduction of more elaborate devices. "Still horses" are now seen only on small children's roundabouts, for many years turned by hand power through reduction bevel gearing, but latterly often converted to electric drive.

The next step in the development of the roundabout was the addition of a galloping action to the horses. Three patents on the subject were taken out within a brief period so that one cannot now say with certainty who first devised "gallopers." In the matter of patent date, however, Frederick Savage led by a few months. He, in a specification of 1885, described a galloping horses machine which was a perfectly practical design, and became quite popular. Later in the same year, Reynolds and King, engineers (who, like the other pioneers, belonged to East Anglia), patented "an improved construction of merry-go-rounds or roundabouts having for its principal object to impart a galloping movement to the horses from above, as they rotate in the usual manner round the central support or pillar." Known in later years as "double-crank gallopers," this class of machine enjoyed brief popularity, but no example is known to survive. Most were later altered to the "single-crank and platform slide" design, in which form one or two still exist.

Reynolds and King, in this machine (a drawing of which appears in Fig. 4), introduced a series of radial crankshafts, each

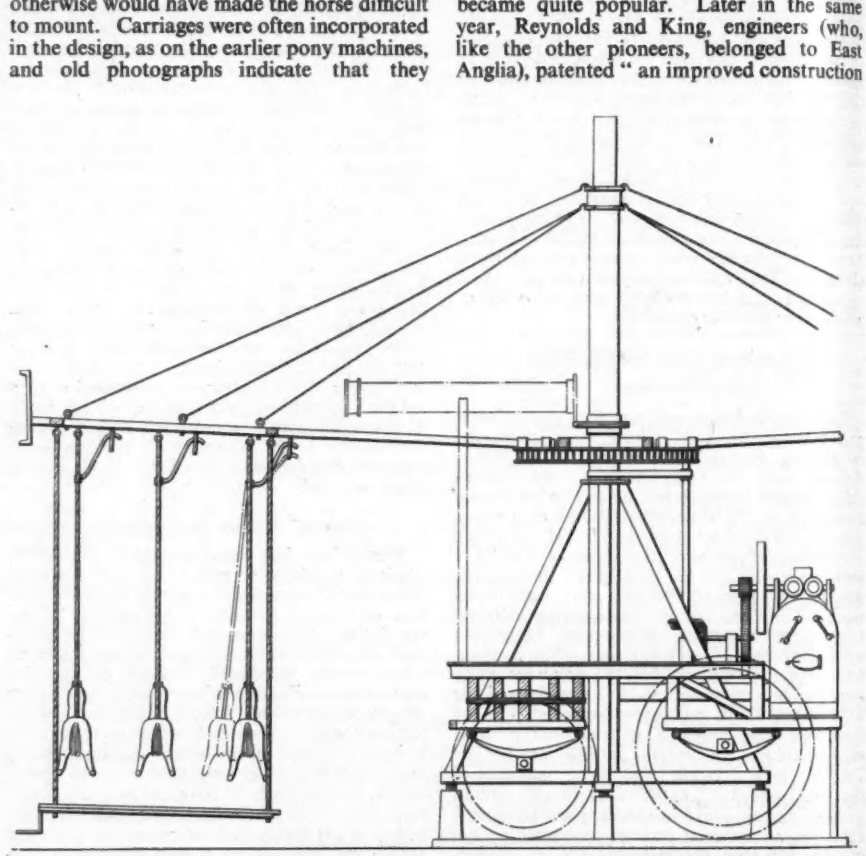
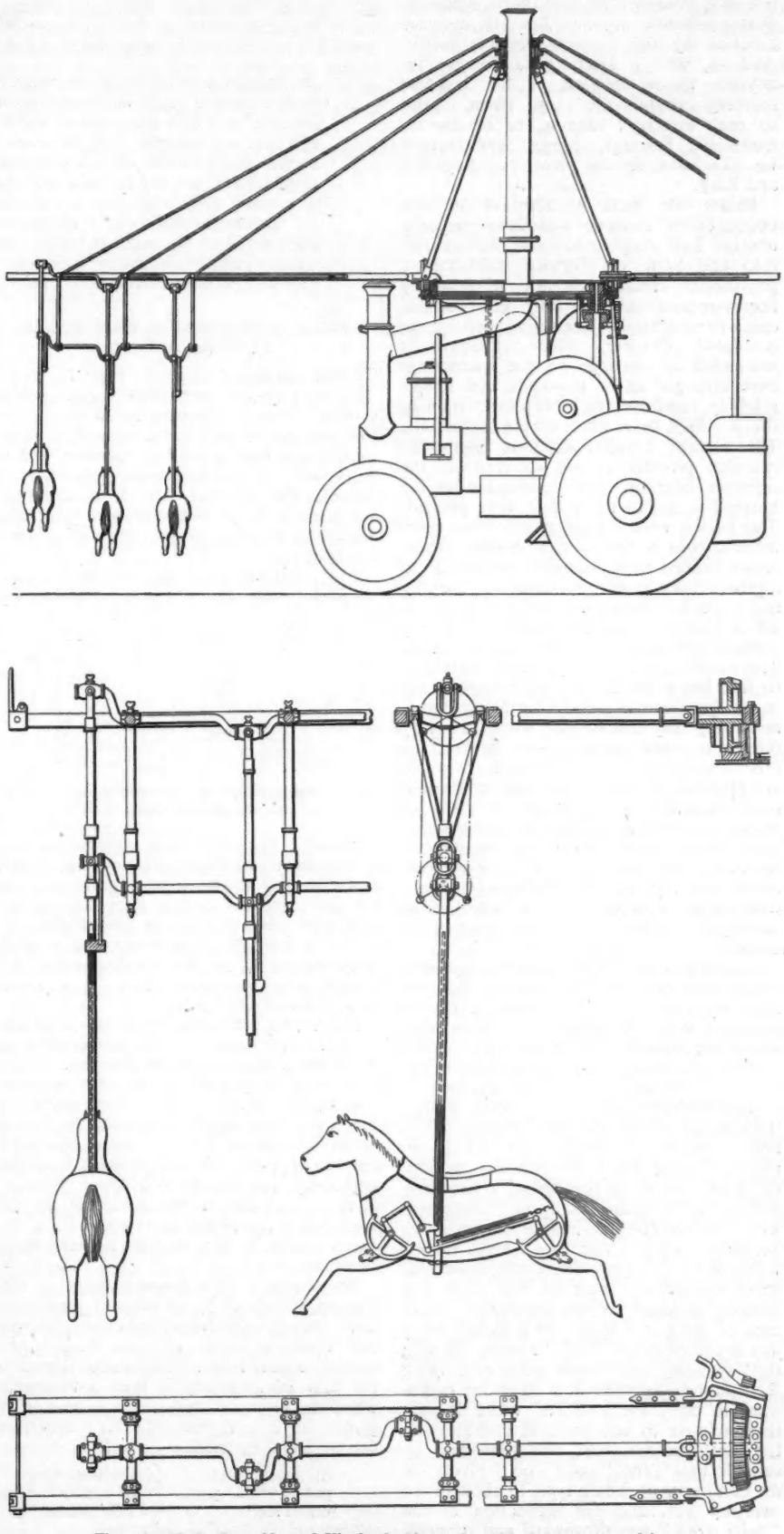


Fig. 3—The earliest powered roundabouts were a direct development of the primitive pony-propelled machines, and here the essentials of a steam "Dobby-horse" set are shown

with as many throws as there were horses abreast, journalled in bearings on the quarterings. Combined friction and toothed pinions on inward extensions of the crankshafts ran around a fixed friction and toothed "face wheel" concentric with the centre pole. The roller race carrying the upper ends of the swifts tie rods was free to slide on the "pole," and the swifts were hinged in the horizontal plane to the cheese-wheel, to permit such movement. Near-vertical struts ran from the race to the frame carrying the inner bearings of the crankshafts; hence the weight of the horses and riders was transmitted first to the top roller race, as on still horses, and thence via these struts to the gearing. Spring-mounted crankshaft bearings were also specified, "thus further ensuring the perfect engagement of the pinions with the combined face tooth and friction wheel." It is apparent that the inventors were preoccupied about this gearing slipping out of mesh, and in view of the amount of friction introduced by the "double-crank" action now to be described, their fears were probably well founded.

At a level about 3ft below the main crankshafts already mentioned, a second circle of crankshafts was arranged, as shown in Fig. 5. In throw and crank setting these were replicas of the main set, and lay directly beneath them, but they were not extended inward to the centre. Each was journalled in two bearings, pivoted to the apexes of a pair of inverted triangular brackets hinged to the quarterings above, and each crankpin bearing on the main (upper) cranks had a vertical rod pivoted to it. This rod was pivoted also to the corresponding crankpin bearing on the secondary (lower) crank, and it continued downward to carry a horse. It will be seen that revolution of the top frame caused the pinions to roll round the fixed face wheel, thus imparting rotary motion to the main crankshaft, and hence to the horses a circular motion which, combined with the rotation of the machine, produced a reasonable approximation to galloping. The function of the secondary crankshafts was to prevent fore-and-aft swinging, and to space the horses radially. As the machine gathered speed, the horses could swing out under the action of centrifugal force, the hinged triangular brackets allowing the secondary crankshafts to move outward, but constraining them to remain horizontal.

It will be seen that the galloping action of the Reynolds and King machine was entirely independent of the platform, which, as in "still horses," served only as an aid to loading, unloading and fare collecting. The specification states that the cranks of any crankshaft are preferably set at different angles; in practice, of course, they had to be, to prevent dead-centre locking, apart from any considerations of balance. Two alternative designs are mentioned; in one the lower (secondary) crankshafts are arranged at a lower level, to pass through the horse bodies, and in the other, at a lower level still, presumably beneath the platform, but no record exists of such arrangements being tried in practice. Additionally, as if the machine were not complicated enough already, means were described for imparting movements to the legs of the horses. Below the level of the pivot of the lower crankpin bearing each horse "rod" was specified to be hollow. A rod inside this hollow column was given reciprocating motion via an eccentric on the crankpin, and its lower end was connected to one arm of a three-armed lever within the horse. The other two arms were linked to the pairs of fore and hind legs, which were pivoted on quadrants. With characteristic thoroughness Reynolds and King suggest that if, as might be done, all the main and secondary crankshafts were made to be of adjustable throw, so that the horses could either gallop or trot, the linkage within the horses should likewise be adjustable, so that the leg motion should be appropriate. No evidence is available to confirm that moving leg horses were ever used in



Figs. 4 and 5—Reynolds and King's double-crank action for horse roundabouts. This was among the earliest galloping motions and enjoyed some popularity until superseded by simpler arrangements with fewer moving parts

practice, and even nowadays horses with rigid legs are accepted without question. Altogether, the "double-crank gallopers" was an ingenious design, but perhaps a little before its time. We regret, perhaps, that its inventors did not appreciate (as did, for instance, Frederick Savage) that a successful fairground ride accomplishes its designed function by the simplest possible means. And so, with a sympathetic thought for anyone whose mission in life included crawling round the top frame prior to each evening's running, to oil the innumerable bearings, hinges and pivots, we take leave, for the present, of Reynolds and King.

Before the final specification of this double-crank machine had been prepared another East Anglian concern, Robert Tidman and Sons, of Norwich, submitted a provisional specification for a galloping horses roundabout with only one overhead crank to each horse. Their final specification is dated October, 1886. Crankshafts journalled in bearings on the quarterings were arranged as in Reynolds and King's machine, and driven by bevel pinions running round a fixed bevel wheel on the centre pole. The vertical horse rods were connected (whether pivotally is not specified) to the crankpin bearings, and terminated at the horses's backs, to which they were pivoted. The horses were rigidly attached to short inclined rods bolted to their bellies; these rods extended rearwards and downwards to a pivot on a crossbar, one crossbar, carrying the pivots for the three "belly irons" of a set of horses, being suspended by two long vertical rods from a swift of the top frame. These crossbars, which, apparently, extended to just below the horse's hind hooves, are in the specification called "Swinging Bars," and swing they undoubtedly would, in every direction, unless restrained by tie rods or other means not specified. In fact, the whole arrangement as described, seems crude and unmechanical; one doubts whether a machine exactly to this design was built or even seriously intended. It is the writer's personal view that Tidman's aim was, understandably, to get a "galloping horses" with single overhead cranks patented as quickly as possible, without worrying about details.

Slightly modified, this design was successful to the extent that a working example survived for sixty years after the invention of the platform slide. One specimen, which the writer inspected about ten years ago, differed from the foregoing patent design only in the following respects:—The horse rods, instead of terminating at the horses' backs, passed through the horses and were pivoted to the belly irons below them. Thus, the horse, although not given a true circular motion, did have something resembling a galloping action, rather than the mere "bucking" which Tidman's original mechanism imparted. Secondly, swinging out, to a limited extent, was catered for by providing long crankpins which carried two bearings, the inner one slotted, attached to the bifurcated upper ends of the horse rods—the principle being just as described for "still" horses. Thirdly, the "swinging bars" were in this case rigid; their supporting rods were extended downward to carry the platform, which located them relative to one another, and sway of the platform and bars was prevented by suitable ties. The "belly iron" pivots (to the bars) were of sliding type, to allow of the swinging out, and the inclination of the "belly irons" was downward and forward, instead of rearward.

(To be continued)

Determination of Economic Steam Cycle for Nuclear Power Stations

No. I

By P. H. MARGEN, B.Sc.(Eng.), A.M.I.E.E.*

In combustion steam stations there has been a trend towards the adoption of single-stage reheating cycles and even two-stage reheating is being considered for a few stations.[1, 2] These developments reflect the endeavour to select the highest cycle efficiencies obtainable with the steels now available. In contrast, most of the nuclear power station projects mentioned in the literature[3, 4, 5] have moderate steam temperatures, are not provided with reheaters and, in at least one case, make use of a steam cycle employing two steam pressures.[3] The present article examines the reasons for this trend of development of the nuclear station steam cycle and discusses how the optimum cycle can be found for any particular conditions. Certain parts of this subject have been discussed briefly in references [6] and [7], but no comprehensive treatment has been published.

Mean Temperature of Heat Intake by Working Fluid

THE schematic diagram, Fig. 1, represents a typical circuit for a nuclear power station. Heat is liberated by fission in the fuel elements located in the reactor, is transmitted to a fluid termed the coolant, and is transported to the heat exchanger where it converts the working fluid from water to superheated steam at one or more pressures. The steam drives turbo-generators of conventional design.

Fig. 2 illustrates the heat cycle for a single pressure plant on a temperature-entropy

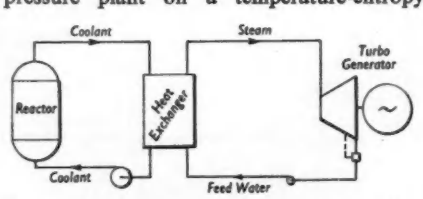


Fig. 1—Schematic diagram of nuclear power station, with one pressure steam cycle

diagram. The top line represents the maximum allowable temperature, θ_M, of the fuel elements at the critical point—e.g. at the fuel core for certain types of reactor and at the fuel containers for other types.

The bottom line represents the vacuum temperature, T_r, in the condenser, i.e. the temperature at which heat is rejected from the working fluid.

Intermediate between these two temperatures lies the curve T, the temperature at which the working fluid absorbs heat. If this curve were to approach the maximum temperature θ_M of the heat source, then insufficient heat would be transmitted to make the station economic. If, on the other hand, the curve were to approach the temperature T_r of the heat sump, then the thermodynamic efficiency of the cycle would be too low. Clearly, the economic value of the mean level, T_i, of the curve would be intermediate between these two cases.

To obtain a first approximation to the economic value of T_i, all costs of generation other than the relatively large capital charges and operating costs for the reactor and cooling circuit may be neglected. The cost per unit of electricity is then a minimum when the electrical output for a reactor of given size is a maximum. This condition can be found by writing

$$\left\{\begin{array}{l}p, \text{ the generator output in MW per ton of fuel}\end{array}\right\} = \left\{\begin{array}{l}q, \text{ the heat rating of the fuel in MW per ton}\end{array}\right\} \times \left\{\begin{array}{l}\eta, \text{ the thermal efficiency}\end{array}\right\}$$

which can be represented by

$$p = \{a(\theta_M - T_i)\} \times \left\{\eta_p \left[\frac{T_i - T_r}{T_i + 460}\right]\right\} \quad . \quad . \quad (1)$$

where

a = constant for a particular reactor and cooling circuit;
η_p = efficiency ratio of turbo-generator and heat exchanger, i.e. the factor allowing for mechanical losses, heat radiation, &c.,
$(T_i - T_r)/(T_i + 460)$ = ideal cycle efficiency, η_i.

As shown later in Appendix 1, the generator output, p, reaches a maximum for given values of θ_M, T_r, a and η_p when

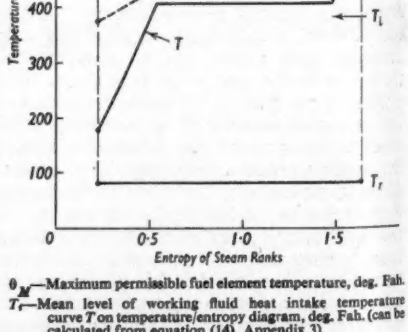
$$\left\{\begin{array}{l}\text{Mean height of steam cycle on temperature-entropy diagram}\end{array}\right\} = R \left\{\begin{array}{l}\text{Overall temperature difference between fuel elements and condenser.}\end{array}\right\}$$

i.e. when

$$(T_i - T_r) = R(\theta_M - T_r) \quad . \quad . \quad . \quad (2)$$

where the factor R lies between 0·37 and 0·43 for the practical range of fuel temperatures (taken as 500 to 1100 deg. Fah.). Hence, $R = 0{\cdot}4$ represents any approximate rule for the determination of the economic mean working fluid heat intake temperature.

To obtain a more accurate rule, the influ-



θ_M—Maximum permissible fuel element temperature, deg. Fah.
T_i—Mean level of working fluid heat intake temperature curve T on temperature/entropy diagram, deg. Fah. (can be calculated from equation (14), Appendix 3).
T_r—Temperature of heat rejection, deg. Fah.
t—Temperature of coolant, deg. Fah.

Fig. 2—Nuclear station temperatures for single pressure steam cycle

* Messrs. Kennedy and Donkin.

ence of T_i on the following relatively small costs must be examined :

(*a*) *Cost of Fuel.*—(i) The net cost of nuclear fuel is the difference between the cost of new fuel elements and the financial value of depleted elements withdrawn from the pile. Where electricity generation is the sole concern, the depleted elements have a relatively low financial value so that the net fuel cost is positive. It is then economic to adopt a slightly higher value of R than 0·4, e.g. a value of 0·45 for the example in Appendix 1.

(ii) Where the nuclear station is required primarily to meet a shortage of plutonium for military equipment, the financial value assigned to the plutonium bearing fuel elements withdrawn from the pile may be much higher than the cost of the new elements. The net fuel cost is then negative, and a value of R less than 0·4 tends to become economic. Once several nuclear stations have been commissioned in any given country this case is not likely to arise.

(*b*) *Capital Costs.*—(i) An increase in T_i imposes higher steam conditions on the heat exchanger and makes it necessary to adopt a more expensive design. This reduces the economic value of R, particularly when high steam conditions are reached.

(ii) An increase in T_i reduces the amount of heat rejected to the condensers and cooling towers, and consequently reduces the cost of these plant items. This increases the economic value of R, particularly when T_i is low, i.e. when the condensers are relatively large.

(iii) At high temperatures effect (i) predominates and at low temperatures effect (ii). In an intermediate temperature range which might be expected to be approximately 350 deg. Fah. $<T_i<$520 deg. Fah., these two effects cancel, so that R would remain unchanged. Where low boiling point liquids are used as coolants, T_i affects also the design pressure of the reactor, thus accentuating effect (i) and reducing the temperature at which effects (i) and (ii) balance.

The above discussion provides a convenient method of assessing the economic value of R, and obtaining the economic mean working fluid heat intake temperature with the aid of equation (2) for given temperature limitations of the fuel elements. Once the economic value of R has been found it is, however, necessary to check that the heat ratings corresponding to this value of R do not impose excessive thermal stresses on the fuel elements.

Comparison With Published Design Studies

In order to examine whether or not design studies described in the published literature have arrived at values of R and T_i conforming with the above discussion, leading particulars of seven preliminary designs prepared by five different organisations have been abstracted and are shown in Table I. The directly published information has been augmented by certain inferred figures shown in brackets, e.g. values of T_i estimated by the author from the published design efficiency in cases where the steam conditions were not given. Caution is, however, necessary regarding these inferred figures.

Design 1 represents approximate figures cited by Sir Christopher Hinton[3] and Sir John Cockcroft[6] for prototype thermal reactor stations. If the author's assessment of T_i from the quoted approximate efficiency is correct, then the design corresponds to a value of R=0·40. This agrees very well with the economic value of R derived from the preceding discussion for very low net fuel costs. The maximum fuel container temperature is restricted to the relatively low value of about 400 deg. Cent. (752 deg. Fah.) because thermal reactors of this kind have a very low potential neutron surplus, so that only materials having very low neutron capture cross sections can be used. The readily available materials having this property suffer from corrosion attack by hot CO_2[9] and high-temperature fatigue, and consequently only moderate temperatures can be used. Experience with container materials will, however, probably result in the use of higher temperatures in later designs, and values of T_i of 400 deg. Fah. or more should then become economic.

The remaining six columns show preliminary designs prepared during 1952 by four industrial groups in the U.S.A. for plants in which the production of plutonium was regarded to be as important or even more important than the generation of electricity. Hence the economic values of R for most of these designs would be expected to be less than 0·4. The actual values of R for the designs include two values below 0·4 (i.e. 0·29 and 0·23), three values slightly above 0·4 (i.e. 0·47 for two designs and 0·52 for the third), and one value far greater than 0·4 (i.e. 0·81). The figure R=0·81 is certainly disturbing, and unless physical limitations exist in this particular design, cheaper electricity could be produced by reducing R so as to make more electricity available for the given reactor and heat exchanger size, fuel temperature and D_2O quantity. Reducing R to 0·45 would, for instance, reduce the cost per kWh by about 30 per cent if the net fuel costs were zero. Somewhat lower cost reductions would apply for positive fuel costs and greater cost reductions for negative fuel costs.

The groups responsible for designs 2 and 3 regard the fuel core temperature as the critical feature of the design and allow 100 deg. or 200 deg. Fah. margin with respect to the temperature at which beta phase transformation occurs in the uranium metal. The reason for regarding the fuel container temperature to be less critical in these two cases may be the use of the inert gas helium with design 2, and the use of enriched fuel with design 3, since enriched fuel provides a greater neutron surplus and thus makes it possible to choose the container material from a wider range of metals.

In fast reactors using liquid metals as coolants the temperature limitation is stated to be set by the corrosion of the coolant, and the values of R for designs 4 and 5 in Table I were therefore computed from equation (2) by assuming that θ_M equals the maximum allowable coolant temperature.

Before the discussion on the economic value of T_i is concluded mention should be made of an investigation of the economic steam conditions for nuclear power stations described in reference [6]. The approach adopted was to extrapolate the steam conditions known to be economic for combustion power stations into the region of lower fuel costs, and to assume that the results would then apply to nuclear power stations having such low fuel costs. This line of approach ignores the influence of the maximum permissible nuclear fuel element temperature on the economic solution. Hence, though it may, fortuitously, give the correct result for one type of nuclear station, it gives the wrong result for others.

Table I—*Analysis of Cycle Temperatures for Published Nuclear Station Design Studies*

	Type of reactor						
	Gas-cooled, thermal		Liquid metal cooled			Water or D_2O cooled, thermal	
			Thermal	Fast			
1. Design number	1	2	3	4	5	6	7
2. Designer	Ministry of Supply[a]		Industrial Groups in the U.S.A.[4]				
3. Main purpose of plant	Possibly power	A	B	C	D	A	D
		Dual purpose, i.e. production of plutonium and power					
Reactor details :							
4. Type of fuel	(Natural) uranium	Natural uranium	Enriched uranium	U235	U235	Natural uranium	Natural uranium
5. Moderator	Graphite	Graphite	Graphite	—	—	D_2O	D_2O
6. Coolant	CO_2	Helium	Sodium	Sodium	Sodium	D_2O	Water
7. Heat output, MW	—	350	1000	450	500	1064	500
Heat cycle :							
8. Critical fuel temperature, deg. Fah. :							
(*a*) In core, or	—	1000	1100	—	—	—	—
(*b*) At surface	752	—	—	—	—	465	(560)
9. Coolant temperature, deg. Fah. :							
(*a*) Reactor outlet	662	650	650	1020	900	440	500
(*b*) Reactor inlet	—	384	300	—	600	388	384
10. Number of steam pressures	Two	One	One	One	One	One	One
11. Steam pressure, p.s.i.g.	—	250	135	—	485	175	165
12. Steam temperature, deg. Fah.	—	525	358	—	750	375	375
13. Feed temperature, deg. Fah.	—	109	(100)	—	350	109	(100)
14. T_1, deg. Fah.	(360)*	365	327	(580)†	473	398	336
15. Vacuum temperature, T_2, deg. Fah.	(100)	109	(100)	(100)	92	109	(100)
16. R	0·40	0·29	0·23	0·52	0·47	0·81	0·47

* Estimated from statement in reference [3] that the thermal efficiency for this kind of plant might be 25 per cent and from the assumption that this efficiency relates to the kWh generated (i.e. not the net kWh sent out).
† Estimated from statements that the overall thermal efficiency is 30 per cent. Figures in brackets are assumed by author.

The Distribution Factor

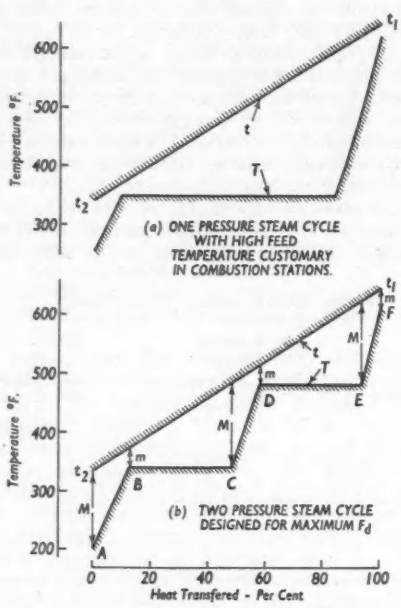
Whilst the preceding discussion has established a simple rule for finding the economic mean level of the working fluid heat intake curve, it is still necessary to determine the best shape of such a curve. If a conventional steam cycle of the kind used in combustion stations were employed, the shape of the curve (on a temperature-heat diagram) would resemble curve T on Fig. 3 (*a*), and the temperature of the reactor coolant would follow the straight line t. The temperature difference between the two curves varies to a marked extent at different points of the heat exchanger, and in consequence the heat transfer surface is not used very effectively. This can be expressed quantitatively by the distribution factor

$$F_d = D_h/D_m \quad \ldots\ldots\ldots \quad (3)$$

where D_h=harmonic mean temperature difference between the two fluids,

$$=(t_1-t_2)\Big/\int_2^1 \frac{dt}{t-T} \quad \ldots\ldots \quad (4)$$

$$=\frac{\text{(heat quantity)}}{\text{(mean heat transfer factor) (transfer surface)}}$$



AB. represents heat intake in l.p. preheater and first preheater.
BC. represents heat intake in l.p. boiler.
CD. represents heat intake in second h.p. superheater and first l.p. superheater.
DE. represents heat intake in h.p. boiler.
EF. represents heat intake in h.p. superheater and second l.p. superheater.

Fig. 3—Heat transfer diagrams

D_m=mean vertical spacing between the temperature heat curves for the two fluids, deg. Fah.

For the conditions shown this distribution factor has the value 0·6.

To improve the distribution factor, a two pressure steam cycle using a circuit similar to that shown on Fig. 4 may be employed. Inspection of the corresponding temperature-heat curves on Fig. 3 (*b*) indicates that the temperature difference is more uniform than with the first cycle, and consequently the distribution factor is increased from 0·6 to 0·86. This increase signifies that the modified cycle :

(*a*) requires about 30 per cent less heat exchanger transfer surface for the same ideal cycle efficiency and coolant temperatures ; or

(*b*) attains an 8 per cent higher cycle efficiency for the same transfer surface and coolant temperatures ; or

(*c*) can produce the same cycle efficiency with the same heat exchanger surface and about 40 deg. Fah. lower coolant temperatures.

It is clear from these points that the increase in the distribution factor has quite marked advantages. If the number of steam pressures is increased from two to a larger number, N, still higher values of F_d can be obtained, until as N becomes very large, F_d tends to unity.

Fig. 5 shows this relation in the form of a chart plotted from the formulæ developed in Appendix 2 to this article. The chart has F_d as ordinate, and $ND_h/(t_1-t_2)$ as abscissa. The lowest curve applies to steam cycles without preheaters or superheaters and the remaining curves apply to steam cycles designed for the feed and final steam temperatures producing the highest values of F_d. It can be shown that this occurs when all the maxima in the distribution of the temperature difference attain the same value, and all the minima attain the same value. These maxima and minima are designated by M and m respectively on Fig. 3 (*b*).

The curves show clearly the improvements obtained by including preheaters and superheaters in the heat exchanger, and by employing several steam pressures.

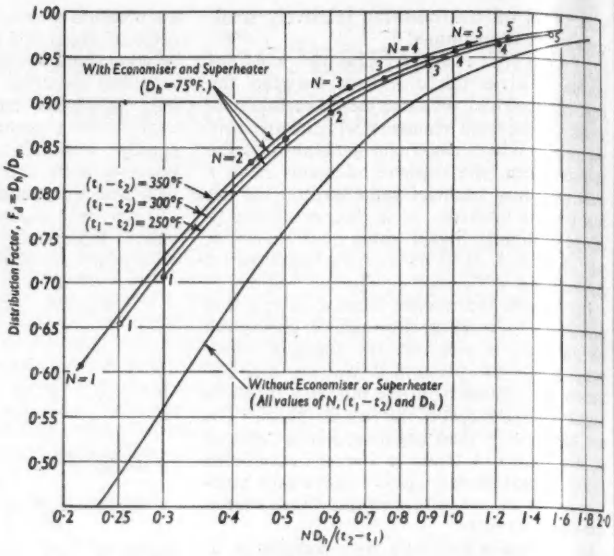


Fig. 5—Chart for determination of distribution factor

Economic Number of Steam Pressures

Table II shows the effect of the number of steam pressures on the ideal cycle efficiency for given values of t_1, t_2, D_h and T_r. Column 1 of the table gives the number of pressures, column 2 the distribution factor, column 3 the ideal cycle efficiency, column 4 the fractional increase in the cycle efficiency resulting from one additional steam pressure, and column 5 the financial value of this increase in efficiency, assuming that one extra MW of power output at, say 80 per cent annual load factor has an annual financial value of £16,000.† The terms in column 5 diminish rapidly, i.e. have the successive values 822, 173, 86 and 43 £ per MW per annum. Somewhat lower values apply for lower values of the ratio $(t_1-t_2)/D_h$.

If the complications to the plant introduced by one additional steam pressure would account for extra capital charges and maintenance costs amounting to say, £300 per MW per annum, then a two-pressure cycle would be economic ; if the amount were only £150 per MW per annum, then three pressures should be selected.

The calculations for Table II are based on turbine arrangement "A" illustrated on Fig. 4, which provides one separate condensing turbine for each steam pressure.

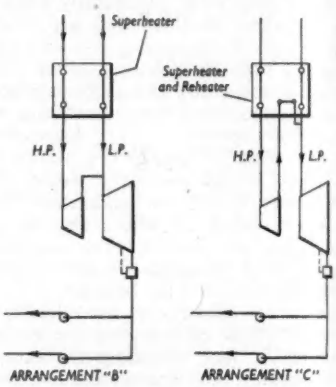
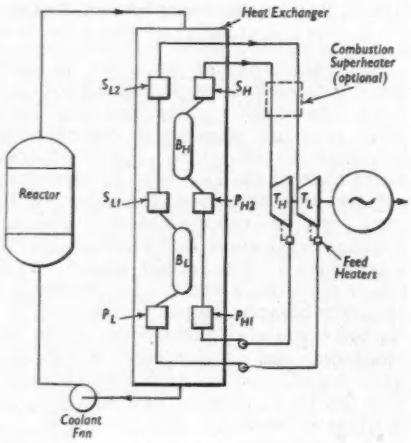


Fig. 6—Other turbine arrangements for two-pressure steam cycle

If arrangement "B", illustrated on Fig. 6 is adopted, i.e. only a single condensing turbine containing N steam inlet points is provided, then an irreversible process is introduced as a result of the mixing of low-temperature steam exhausted from the first turbine cylinder with the high-temperature steam leaving the low-pressure superheater. This irreversible process reduces the performance gains obtainable from the additional steam pressure to about 87 per cent of the amounts for arrangement "A." Arrangement "B" is one of the circuits



P—Preheater.
B—Boiler.
S—Superheater.
Suffixes *L* and *H*—Low and high pressure, respectively.

Fig. 4—Schematic diagram of nuclear power station circuit with two-pressure steam cycle and two condensing turbines. (Arrangement "A.")

Table II—*Financial Value of One Additional Steam Pressure*

Assumed conditions : t_1=640 deg. Fah., t_2=340 deg. Fah., D_h=75 deg. Fah., T_r=80 deg. Fah., Z=£16,000 per MW per annum; N=number of condensing turbines ; see Appendix 3 for method of calculating η_t

1	2	3	4	5
Number of steam pressures, N	Distribution factor, F_d	Ideal efficiency, η_t	$\frac{(\eta_t \text{ for } N)-(\eta_t \text{ for } N+1)}{(\eta_t \text{ for } N)}$	Financial value of one additional pressure ± (Col. 4) × 16,000 £/MW per annum
1	0·651	0·350	0·0513	822
2	0·861	0·368	0·0108	173
3	0·927	0·372	0·0054	86
4	0·957	0·374	0·0027	43
5	0·971	0·375	—	—

† This amounts to the total value of 1MW of power less the capital charges on 1MW of turbo-generator capacity needed to make the extra power available.

recently described by Sir Christopher Hinton.[8]

Arrangement "C," also shown on Fig. 6, is similar to "B," except that the steam exhausted from the first cylinder is reheated before being mixed with the high-temperature steam, in order to avoid the irreversible mixing process referred to above. The reheating also slightly improves the distribution factor and reduces the wetness of the steam in the low-pressure stages of the turbine. The overall effect of these three factors on the turbine efficiency is estimated to have a financial value of £270 per MW per annum, so that the reheater would be justified provided the capital charges on the additional piping, &c., do not exceed this figure. Without a detailed study of plant layout to determine piping costs it is not possible to determine which of the three arrangements is the most economic.

REFERENCES

1 "A New Power Generation Milestone," *Electrical World*, Vol. 139, 1953, No. 26, page 72.
2 Brown, T. W. F., "High Temperature Turbine Machinery for Marine Propulsion," *The Chartered Mechanical Engineer*, Vol. 1, April, 1954, No. 4, page 162.
3 Hinton, Sir Christopher, "Nuclear Reactors and Power Production," *The Chartered Mechanical Engineer*, Vol. 1, May, 1954, No. 5, page 235.
4 Reports to the U.S. Atomic Energy Commission on Nuclear Power Reactor Technology by Four Industrial Groups. *A.C.E.*, May, 1953 (Abstract in *Nucleonics*, Vol. 11, June, 1953, page 51).
5 Smyth, H. D., "The Development of Nuclear Power for Peaceful Purposes," *Electrical Engineering*, Vol. 73, June, 1954, page 498.
6 Elliott, R. D., "Economics of Steam-Temperature Selection in Nuclear Power Plants," *Nucleonics*, Vol. 10, February, 1952, page 57.
7 Robbins, C. H., "Low Temperature Steam Power Cycles for Water Cooled Reactors," *Nucleonics*, Vol. 11, January, 1953, page 42.
8 Cockcroft, Sir John, "Atomic Power Stations," *The Times Electricity Supplement*, December, 1953.
9 Cockcroft, Sir John, "Atomic Energy Research at Harwell," *Atomic Scientists Journal*, Vol. 3, No. 4, 1954, page 182.

(To be concluded)

3000 E.H.P. "Eland" Turbo-Propeller Engine

Details have been released by D. Napier and Son, Ltd., of the "Eland" turbo-propeller engine, which develops 3007 e.h.p. (sea level static) for a weight of 1575 lb. The engine is distinguished by its low specific weight and in having a compressor of unusually high performance per stage. Although its layout is conventional, the engine mounting, the reduction gearing and the turbine blading are amongst several items of special interest. The engine has a maximum speed of 12,500 r.p.m. and a cruising fuel consumption of 0·49 lb/e.h.p.-hr.

THE most recent of the prime movers developed by D. Napier and Son, Ltd., Acton, is the "Eland" propeller turbine engine of 3000 e.h.p. This unit, which has now been approved for flight testing, is the result of a broad and intensive aerodynamic and mechanical research programme on component design upon which the company's aero gas turbine division has been engaged in recent years.

Among the notable aspects of its design and performance is the achievement of a compression ratio of 7 : 1 at a mass flow of 31 lb per second, with only ten axial stages, which the company believes represents the highest performance per stage of any known gas turbine. Its specific weight, given at 0·55 lb per e.h.p., is appreciably lower than that quoted for other turbo-propeller units and its fuel consumption and specific frontal area compare with the best yet achieved in this class of prime mover.

Constructional Details

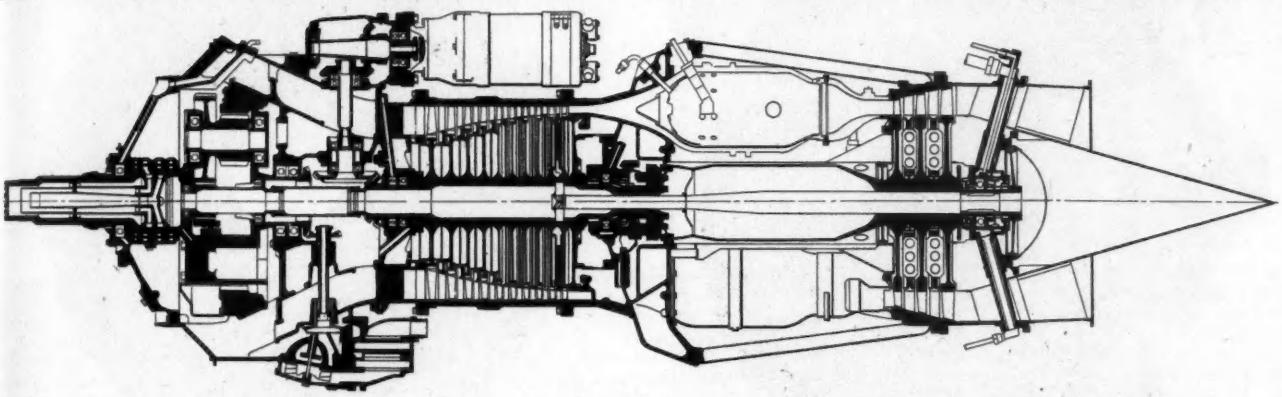
The "Eland" is a single shaft unit of conventional layout and has the following dimensions and weights :—

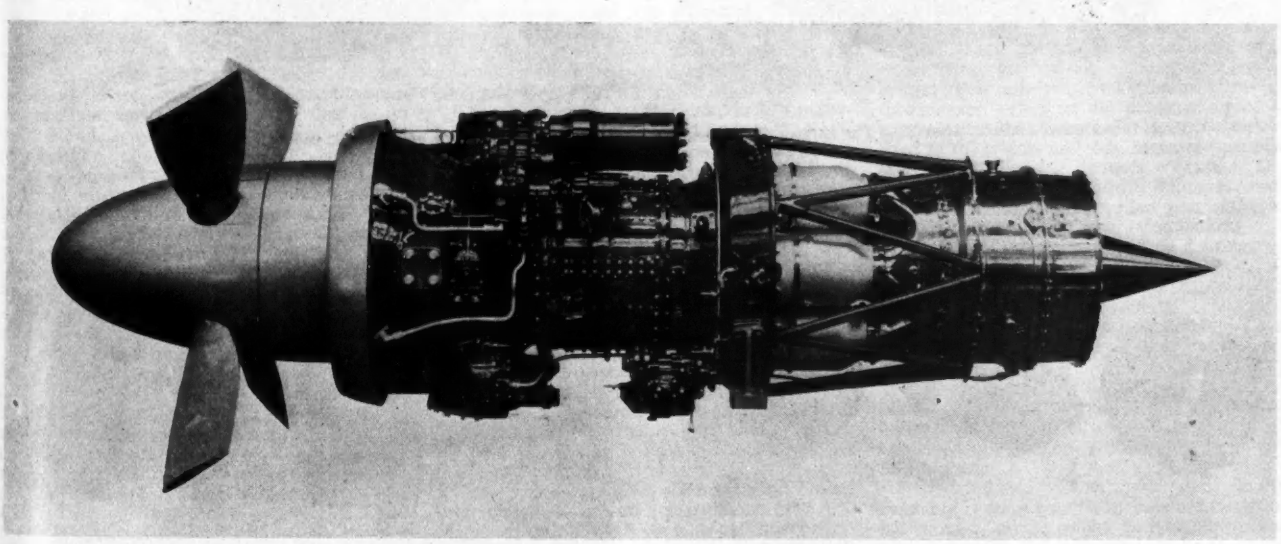
Maximum diameter	36 1/4 in
Length (front of propeller shaft to turbine exit flange)	105 1/4 in
Length (front of propeller shaft to end of turbine exit tail cone)	122 1/4 in
Overall frontal area (including accessories)	7·1 sq ft
Net dry weight, less jet pipe (to EDM No. 25)	1575 lb ±2½ per cent
Complete with starter and propeller governor	1661 lb
Jet pipe (per foot run)	7·6 lb

In the design particular attention has been given to the requirements of servicing and overhaul. The engine is divided into four major assemblies, comprising reduction gear, compressor, combustion system and turbine. Each major assembly can be replaced individually so that, for example, when the turbine is removed the reduction gear, compressor and combustion system need not be disturbed. The combustion chambers and burners are separately removable for inspection or replacement and free access is available to all engine accessories.

The engine consists of a ten stage, axial-flow compressor, six combustion chambers, and a three stage turbine, the air mass flow having a straight through path with no sudden changes in direction. The compressor and turbine are mounted coaxially and a single-rotation, constant speed propeller is driven through a reduction gear. Control of the engine is effected through an interconnected fuel metering unit and propeller governor, operated by a single lever. Automatic compensation is provided for changes in forward speed and ambient temperature and pressure conditions.

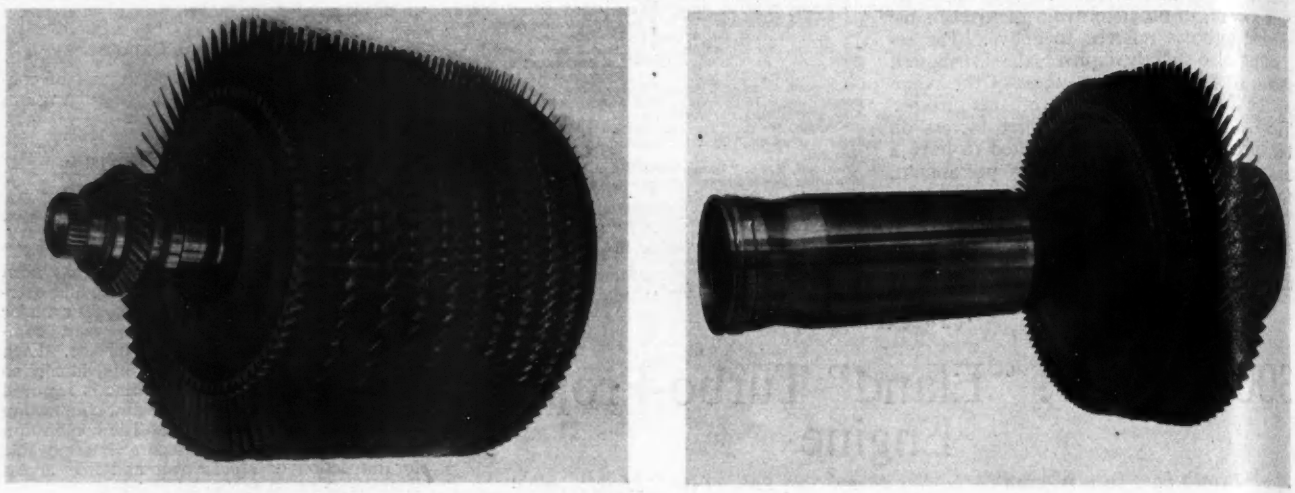
Air is delivered to the compressor through an



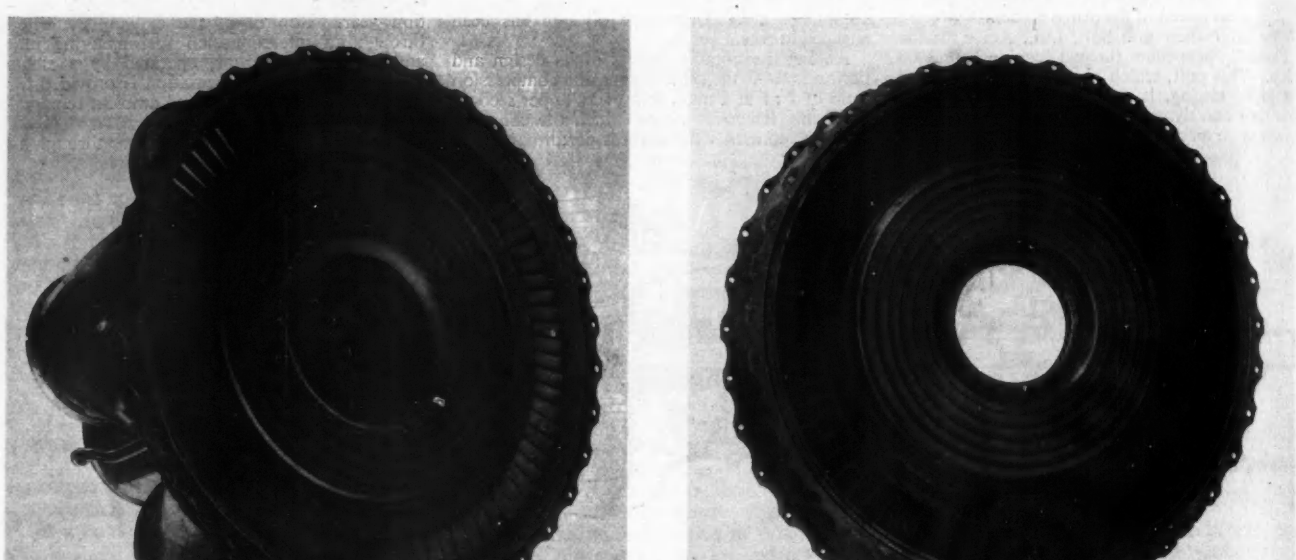


The "Eland" turbo-propeller engine of 3000 e.h.p. It weighs 1661 lb (as shown in the sectional drawing), its maximum diameter is 36in and its fuel consumption (cruising) 0·49 lb per effective horsepower-hour

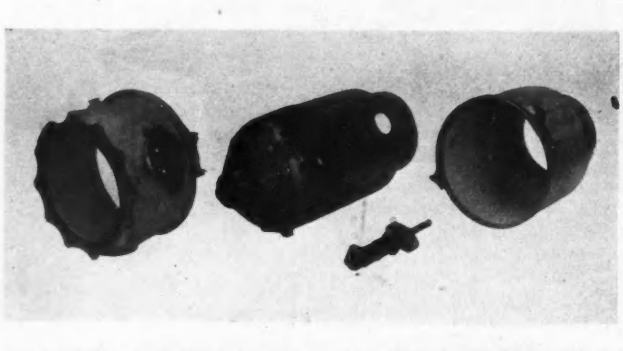
THE NAPIER "ELAND" TURBO-PROPELLER ENGINE



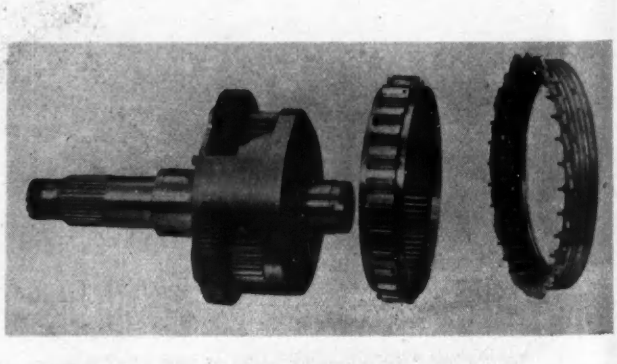
Rotor assembly showing compressor with accessories drive pinion, the gear coupling and the three-stage turbine. Method of cooling turbine blade roots can be noted



Stage 1 and stage 2 nozzle assembly. The methods of locating the blades can be distinguished and the disc cooling scrolls on the sealing plates are clearly shown



Combustion chamber with upstream fuel injector, showing fabrication to facilitate withdrawal of chamber through turbine frame



Internal and external rings of the torquemeter and the reduction gear

annular, forward facing intake which surrounds the reduction gear casing immediately behind the propeller, and is designed to take full advantage of ram effect at forward speed. The intake, in common with all other gas passages, has been flow tested and developed for maximum efficiency before incorporation in the final design.

Protection against icing of the intake and compressor inlet has been given careful study. The inner wall of the intake is heated by reduction gear oil splashed on the casings. Jackets have been designed for the outer wall of the intake through which reduction gear scavenge oil is circulated before being returned to the cooler. This scavenge oil is also circulated through the noses of the six spats in the intake which house the accessory drives and other essential services. The compressor inlet guide vanes are anti-iced by air tapped from a suitable stage in the compressor; the air heats both leading and trailing edges of the vanes before exhausting into the main stream at the inner diameter.

Compressor.—The company explains that compressors to suit an engine of given mass flow can vary between low hub/tip ratio, high speed, small diameter and high hub/tip ratio, low speed, large diameter designs. In turbo-prop applications the former, although giving a lighter compressor requires a larger reduction gear ratio and heavier gearbox. The final design should, therefore, be a compromise to obtain the minimum engine weight. For this reason the "Eland" compressor has been designed for a medium hub/tip ratio of 0·7.

The compressor characteristics obtained give optimum efficiencies on the engine operating line which is well removed from surge. The margin from surge is further increased at low engine speeds by the use of variable inlet guide vanes and as a result extremely good engine handling and acceleration responses are obtained without danger of surge. The inlet guide vanes are controlled by a speed sensing servo unit.

A design pressure ratio of 7·0/1 has been achieved at 31 lb per second mass flow for the take-off rating with only ten stages of blading. The compressor is of simple construction, comprising a disc and shaft rotor with two half-casings to which are bolted the stator rings. A half-casing is illustrated on this page.

Aluminium-bronze blades are used throughout and all the rotor blades are secured by fir-tree roots to the compressor discs, as can be seen in the illustration of the rotor. These, in turn, are located over flank fitting splines to a hollow rotor shaft of S107 steel. For stages 1 to 7, the rotor discs are of aluminium and the remainder are of steel. The stators, which are of shrouded construction for the first four stages and cantilever for the remainder, are contained in the two halves of the L51 alloy compressor casing.

A ball and roller bearing at the front and a roller bearing at the rear, support the compressor rotor shaft, which is connected to the turbine by a gear coupling.

To prevent windmilling while the aircraft is on the ground, a parking brake is fitted to the rear end of the compressor shaft and is shown in the view of the support plate.

Support Plate.—Provision is made for mounting the engine from three pads on a support plate situated at the rear of the compressor. This casting in Z.T.1 light alloy, which is shown below, includes the diffuser, between the compressor and combustion chambers, and an internally cast annulus into which air is bled from the diffuser for turbine cooling and cabin pressurisation.

Combustion Chambers.—The combustion system, designed in conjunction with Joseph Lucas, Ltd., comprises six tubular chambers fitted with upstream injection burners. Each chamber and burner, as shown on the opposite page, can be separately removed without dismantling any other engine part. To facilitate withdrawal through the turbine frame each chamber is secured at either end by clamping rings.

The outer castings are fabricated in S.84 material and the flame tubes in D.T.D. 703. High-energy, spark-ignition plugs are provided in two of the combustion chambers from which the flame is propagated to the remainder by interconnectors. The use of upstream injection burners, it is maintained, not only reduces the overall length of the system but gives good combustion at very high air/fuel ratios.

The engine operates satisfactorily on either kerosene or wide-cut fuels.

Turbine.—To achieve the maximum output from the turbine, without excessive weight penalty, a three-stage reaction turbine has been used at an expansion ratio of 5·5/1, with zero swirl to minimise jet pipe loss and turbine back pressure. To reduce the back pressure the final jet velocity is kept low relative to the turbine exit velocity.

The turbine comprises three separate, bladed rotor discs mounted on a shaft and carried in a fabricated casing which contains the three nozzle assemblies. The rotor discs, of H40 material, are mounted as illustrated over flank fitting splines on the turbine shaft which is supported at the rear by a ball bearing and, at the front, by the gear coupling driving the compressor. The combined rotor assembly (compressor and turbine) is mounted on three bearings and so arranged that the gyro-couples at the centre bearing are in general cancelled.

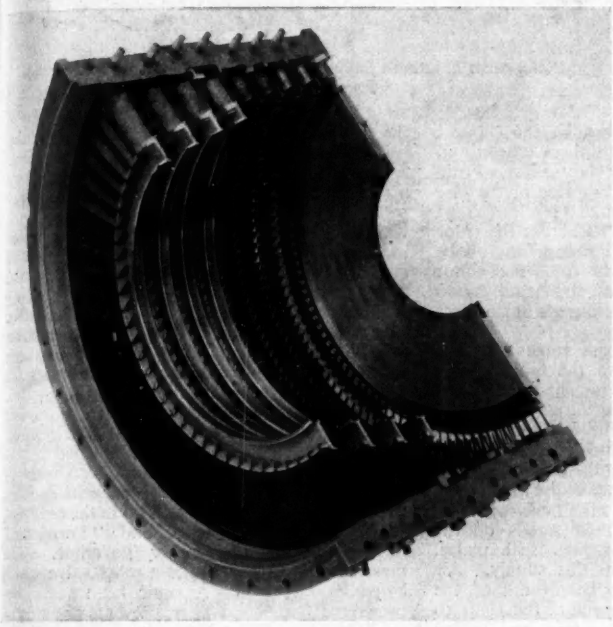
The rotor blades, which are of Nimonic 90 in stage 1, and Nimonic 80A in stages 2 and 3, are secured to the discs by fir tree roots, and so fitted that a limited amount of tip rock is obtained. This arrangement allows for the differential expansion of the blades and discs, relieves root stresses and ensures a large measure of vibration damping.

Hollow nozzle blades cast in X40 material are used, but the first stage blades, which are secured by inner and outer rings, as can be seen on page 116, differ from stages 2 and 3, which have inner and outer platforms and are bolted to the external casing. The inter-stage seal plates, shown also in the stator illustrations, which carry seals at the inner diameter and cooling scrolls on each face, are mounted from the nozzle rings by swinging links attached to several of the blade roots, an arrangement which permits differential expansion and ensures concentricity of the seals under operating conditions.

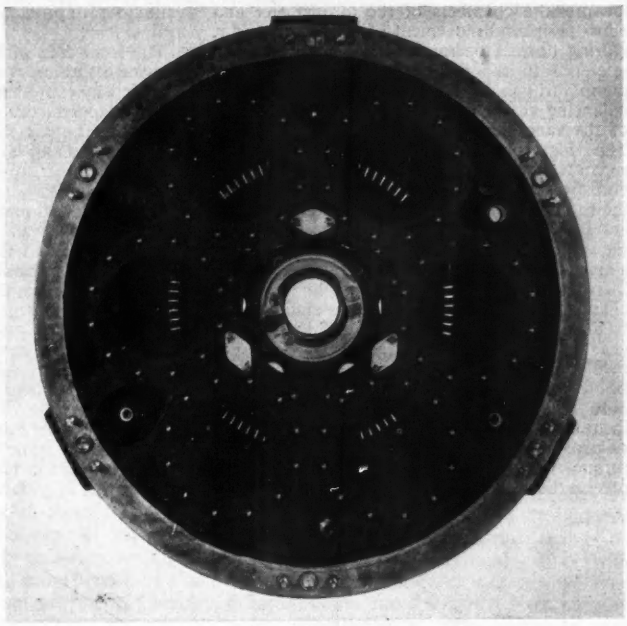
Reduction Gear and Torque Meter.—The reduction gear has a low noise level and a high mechanical efficiency. These important qualities result from the use of a compound-layshaft epicyclic gear train which incorporates a hydraulic torquemeter. Due to the construction of the torquemeter the gearing is not mechanically fixed to the casing, and this, together with other self-centring devices, reduces vibration to a minimum and considerably improves transmission. Alternative reduction gear ratios are available to suit different installations. An illustration of these components and a schematic diagram are reproduced.

A magnesium casting houses the reduction gear and incorporates the air intake. From the compressor the drive is taken through a quill shaft to a high-speed input pinion which is supported at the rear end by a ball bearing and, at the front, by a roller bearing, and drives three planet gears having integral layshafts. Each layshaft is mounted on two roller bearings and carries a planet pinion meshed with the internal annulus gear.

The combined planet gear and layshaft assembly is carried on roller bearings in the two halves of a carrier which is integral with the propeller shaft and supported at the front by a roller bearing, and, at the rear, by a ball and roller bearing in the reduction gear casing. The



Compressor half-casing and stators, showing shrouded construction for front stages, the rear stages having cantilevered blading



Rear view of support plate and parking brake

ball bearing absorbs the propeller thrust. Oil is delivered to the propeller hub through a feed in the propeller shaft and a transfer bearing mounted, in the nose piece of the casing, on rubber rings. The rings act as an oil seal and, in addition, prevent any load from being taken by the transfer bearing instead of the roller bearing.

At the rear end of the propeller shaft a bevel gear drives the oil pump assembly on the bottom cover; the accessories on the top cover are driven by a similar gear on the compressor shaft.

The torquemeter, which is built into the reduction gear annulus gear, consists of an annulus gear and a torque ring, each having several vane shaped members carrying spring-loaded sealing vanes, some of which are removed in the illustration. The annulus gear is located inside the torque ring so that the vane shaped members of each are interposed and spring loaded against the annular walls between the opposite members by the sealing vanes. Between the vane shaped members are spaces which form the high and low-pressure chambers of the torquemeter and allow peripheral movement of the annulus gear. During normal operation oil is supplied (with reference to the diagram) by a high-pressure pump through inlet ports to the high-pressure balancing chambers, and leaks across the sides of the vanes to fill the low-pressure chambers. The high and low-pressure chambers are separately interconnected by annular passages and drain oil escapes through exhaust ports in the torque ring front cover to the engine sump.

As the torque increases on the annulus gear, the vanes move in relation to those on the torque ring, increasing the inlet port area, and thereby increasing the oil pressure in the high-pressure chambers until the pressure is sufficient to balance the torque. Movement of the annulus gear also increases the exhaust port area to facilitate drainage of the now greater leakage of oil from the low-pressure chambers.

In the reversed torque condition, the ports in use for normal torque are closed by the relative movement of the annulus gear and torque ring, and other ports are uncovered to reverse the functions of the high and low-pressure chambers. To obtain normal torque function, a shuttle valve is incorporated in the system so that high-pressure oil is still fed to the differential pressure valve.

By suitable connections to the pressure balancing chambers the torquemeter can be used to give signals for operating safeguard devices in the event of component failure.

From the curves reproduced it will be noted that although the differential pressure signal from the torquemeter is linear with torque, the low-pressure signal has its peak at zero torque. This is a feature of the porting design. It will be realised, therefore, that if failure occurs, the torquemeter low-pressure signal will alter from a point such as *P* to a value *Q*. The safeguard unit consists of an arrangement which moves to the "guarding" position when the low pressure is above the level *XY*. The safeguard unit is rendered inoperative by a cock during starting and running up. Engine tests have consistently shown that the accuracy of the torquemeter over the normal power range is within ±1 per cent of the calibrated dynamometer readings.

Engine Cooling, Pressure Balancing and Sealing.—Air is bled from the compressor to cool the turbine rotor discs, to supply air to the turbine and compressor balance pistons, to cool the compressor rear bearing and turbine bearing, and to supply air to the inlet guide vanes to give protection against icing.

The front face of the first-stage turbine rotor is cooled by compressor exit air, tapped from the diffuser. The air passes through the support plate annulus and is taken by three tubes to an annular chamber forward of the turbine. From here it flows between the front face of the disc and the front seal plate, through a scroll attached to the seal plate and exhausts across the rotor blade root gills to the trailing edge, as can be realised from reference to the rotor and stator illustrations. The object of this scroll is to lengthen the path of the cooling air up the face of the disc.

Further air is tapped from stage 9 of the compressor, and passes into the hollow shaft through a static shroud. This shroud contains vanes which remove the free vortex flow which would otherwise exist in the air and thereby increases the static pressure available. The rear face of stage 1 disc, both faces of stage 2 disc and the front face of stage 3 disc are cooled, by the air passing through scrolls on the inter-stage seal plates, from this supply. Air also passes out of the rear end of the shaft to pressurise the turbine balance piston chamber.

The turbine bearing and the rear face of the last-stage turbine disc are cooled in series with air taken externally through a pipe and filter from stage 4 of the compressor. Tappings from the filter supply the compressor rear bearing with cooling air, and pressurise the seals on the airscrew and accessory bearings.

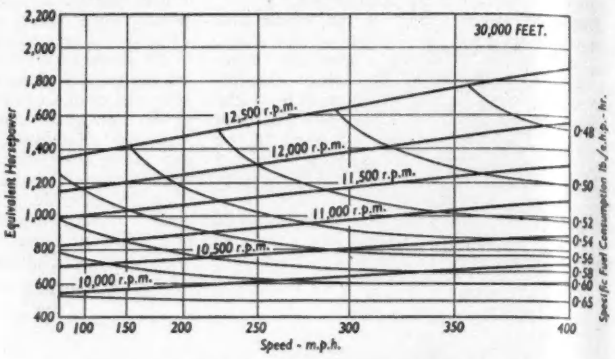
To heat the inlet guide vanes and to supply the compressor balance piston, air is taken forward through the hollow shaft from stage 5 of the compressor. No vortex breaker is fitted in this system as the mass flow and pressure required are relatively low.

Both the inner cone and the jet pipe, which has a propelling nozzle, are of Nimonic 75.

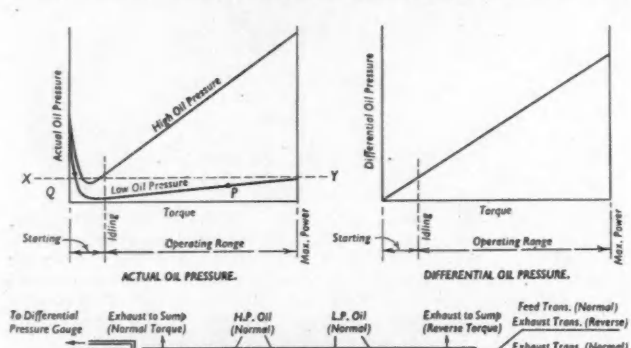
Accessories.—The engine accessories are mounted on the reduction gear casing disposed in two groups around the compressor, as shown in the general arrangement.

Of these, the fuel pump, tachometer, propeller governor, synchronising alternator and an aircraft accessory gearbox drive shaft capable of transmitting 250 s.h.p., are mounted on the top of the casing and are driven by a spiral bevel gear from the front end of the compressor shaft. The design of this bevel drive is unusual in that the thrust is taken by locating cones on each gear, which help to ensure correct meshing, simplify fitting. The cones also carry out the function of an additional thrust bearing.

At the bottom of the casing the pressure oil pump, torquemeter pump and scavenge pumps are all driven from the propeller shaft by spiral bevel gears. An electric starter is mounted above the front end of the compressor, and motors the engine through the accessory gearbox drive.



Performance at altitude for various engine revolutions per minute



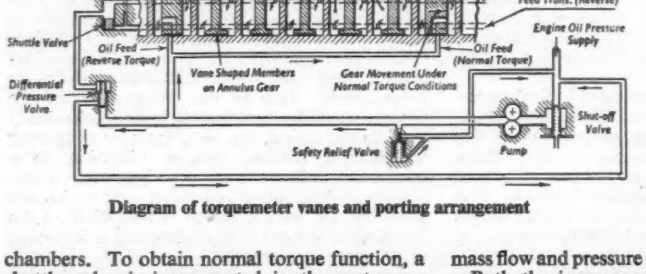


Diagram of torquemeter vanes and porting arrangement

Control.—Control of the engine is effected by a single lever operating an interconnected propeller governor and Napier fuel metering unit, which automatically compensates for changes in forward speed and ambient temperature and pressure conditions. An acceleration control is included in the unit to prevent overfuelling and surging of the engine during acceleration. The fuel metering unit is reset by a two-position lever in the cockpit when compressor air is taken from the support plate for cabin pressurisation. A variable-datum turbine inlet temperature control, a maximum torque limitation device, automatic pitch coarsening, and an inlet guide vane control, responsive to engine speed, are also fitted.

Lubrication.—The engine is supplied with oil from a pressure pump at 80 lb per square inch, which, through a filter, delivers oil to the bearings, gears, torquemeter pump, and "Purolator" filter feeding the propeller governor. The pressure pump incorporates a relief valve which by-passes excess oil. A static head valve, between the pump and filter, prevents flooding of the engine by oil from the tank when shut-down.

Lubrication of the reduction gearing is effected by six sparge type jets mounted on the planet carrier and by impinging jets which feed the planet shaft bearings; the high-speed pinion bearings and propeller shaft front bearings are splash lubricated. Calibrated jets supply oil to the compressor and turbine shaft bearings and to the rear bearing on the propeller shaft. The accessory drive gears and bearings are lubricated by splash oil and calibrated jets.

Engine scavenging is effected by a gear pump which returns the oil from the sump to the tank through a de-aerator, and oil-heated jackets on the intake casing. Both compressor and turbine bearings are independently scavenged by vane pumps which return the oil to the engine sump. The reduction gear chamber is vented through a centrifugal impeller breather which separates the oil from the air before exhausting the air to atmosphere.

The accompanying table and graph present further performance characteristics of the engine. (The maximum cycle temperature is not disclosed).

Sea Level, Static (*I.C.A.N. Atmosphere*)

Take-off (12,500 r.p.m.)	2690 s.h.p. at 0·697 lb/s.h.p.-hr 3007 e.h.p. at 0·624 lb/e.h.p.-hr
Maximum continuous (12,000 r.p.m.)	2070 s.h.p. at 0·744 lb/s.h.p.-hr 2340 e.h.p. at 0·659 lb/e.h.p.-hr
Cruising (11,500 r.p.m.)	1665 s.h.p. at 0·781 lb/s.h.p.-hr 1890 e.h.p. at 0·688 lb/e.h.p.-hr

Altitude (30,000*ft*, 400 *m.p.h.*, *T.A.S.*, *I.C.A.N. Atmosphere*)

Operational Necessity (12,500 r.p.m.)	1575 s.h.p. at 0·554 lb/s.h.p.-hr 1880 e.h.p. at 0·463 lb/e.h.p.-hr
Maximum continuous (12,000 r.p.m.)	1325 s.h.p. at 0·566 lb/s.h.p.-hr 1570 e.h.p. at 0·478 lb/e.h.p.-hr
Cruising (11,500 r.p.m.)	1130 s.h.p. at 0·573 lb/s.h.p.-hr 1310 e.h.p. at 0·493 lb/e.h.p.-hr
Oil consumption (cruising r.p.m.)	1 pint/hr

Battle of the Boilers

By ENGINEER REAR ADMIRAL SCOTT HILL, C.B.E., M.I.Mech.E.

No. II—(*Concluded from page 86, July 16th*)

The story of the Battle of the Boilers has been recorded before. The interest of this account lies in the fact that the author served in ships with Belleville boilers, just those boilers that, having been adopted by the Admiralty, were subjected to heavy criticism and which were subsequently rejected. His contention seems to be that the adverse criticism was not justified, that the boilers were ill-used and that they got a bad name because the ships in which they were installed suffered from other troubles having nothing to do with the boilers.

Service Experience

At first it was not understood how greatly the efficiency of water-tube boilers depends on their being worked at a high proportion of their designed output, though service conditions frequently involve the connection of more boilers than are actually required for economic steaming. During the acceptance trials of "Spartiate," in 1903, the advantage of maximum output per boiler was demonstrated. Somewhere to the west of Land's End, extreme condenser troubles developed, the density at the condensers almost defying the Service hydrometer. The contractors, Messrs. Maudslay, were then in liquidation, and Gaudin had been appointed to act for the receivers, and so was endowed with unusual authority in relation to the dockyard officers. In this emergency they would have jogged home with all boilers connected and in use, and therefore circulation at a minimum or near standstill. He insisted, however, on reducing the number in use to the least required, if forced, for a reasonable speed, with the result that, owing to the rapid circulation, salt was deposited to a depth of nearly an inch on nearly all the tubes, and not only at water gauge level, as would have been the case if steaming easily. What is more no tubes or joints gave out, and all were repairable, though many were badly bent.

Repairs having been completed and final trials been carried out satisfactorily, "Spartiate" commissioned for a "trooping" trip to Hong Kong with relief crews for ships on the China station, in company with the "Europa" similarly engaged. On the return voyage both ships were to carry out a series of trials. The crews embarked were new to the boilers, and at least half the stokers were newly entered "second-class" and wholly inexperienced. But as the crew for the homeward journey would be mainly seasoned men from the Belleville boilered battleship "Ocean," the trials could be looked forward to with some confidence.

After a fortnight in Hong Kong making good large main steampipe joints—a frequent trouble in those early days of higher steam pressures—the relieved crews embarked, and the two ships sailed for home, having the run to Singapore at economic speed to "shake down."

The trials carried out were :

Three runs of eight hours each at full speed ; fifty-four hours at three-fifths power ; thirty-two hours at three-fifths power ; four-fifths power on the last lap—Gibraltar to Devonport.

The new crew proved at first a great disappointment, as they had been brought up to put no trust in their automatics, but to treat their boilers as if they were cylindrical, and only to be forced at the quarterly trials. However, by the time Singapore was reached, they had been bullied into leaving the automatics alone, and into firing and cleaning the furnaces in the way already proved successful in "Spartiate." At full power "Spartiate" developed 18,000 i.h.p. and made 20·75 knots, the "Europa" less, but still a creditable speed allowing for the boilers of earlier design, and troubles other than those due to her boilers. All "Spartiate's" trials were completely successful. On the outward trip she had burnt 2600 tons of coal for 13 knots, the "Europa" 3600 for 10·75. On the return 10,000 miles "Spartiate's" figure was 4500 and "Europa's" 5600. Up to the date the nearest comparable figure was 4000 tons by the "Blenheim" for the outward run.

The appalling fuel consumption of some of the earlier water-tube boilers was largely due to insufficiently covering the wide furnaces and to neglect of thorough cleaning at the sides—thus reducing the effective grate area. In addition, the prevalence of leaky joints and condensers involved extra distilling. Smokebox doors, too, were often too light and did not close properly, while distrust of the automatics led to priming. Incidentally, it was one of Gaudin's maxims that the proper place of the engineer officer of the watch was far more in the boiler-room than the engine-room, where the E.R.A.s could be quite well left to look after the engines, except on entering or leaving harbour, or at action stations.

The good fuel results of these trials, and "Spartiate's" successful trials generally, were regarded with doubt and even suspicion in some quarters. But, as evidence of the genuineness of her coal economy (which would be appreciated by engineers and others of the coal-burning era) there can be quoted the fact that, arriving at Gibraltar and coaling before her record run home, she "coaled" at a rate that entitled her name to be placed on the board then kept at the end of the Mole, as having beaten all the regularly commissioned ships of the Mediterranean Fleet up to that date—proof that she had not acquired any "plush" or excess coal. Fortunate in her chief engineer, she was also fortunate in her commander, the enthusiastic and original Guy Gaunt, and by the time she reached home the morale and esprit of the ship were of an order only achieved as a rule halfway through a commission.

Her small staff of permanently appointed officers and men again became the nucleus of a new complement of "second-class" stokers and inexperienced ratings to prepare for the annual manœuvres, joining up with the regularly commissioned ships of the Channel Fleet. Not only did "Spartiate" give satisfaction, but, on a run to the Canaries, when the order came to proceed independently at full speed, she showed her heels to the more recently built flagship—"Bacchante"—and was promptly detached on an independent mission.

A major defect of all cruisers of that period was the distribution of their coal into a large number of awkwardly placed and small and remote bunkers. In consequence, on any prolonged passage at half speed or over, an increasing number of hands had to be borrowed from the upper deck to trim coal—this, in spite of the large engine-room complements—600-odd in "Good Hope." During this run to the Canaries, when "Action" was sounded, and all engine-room hands went below, the seamen emerged from the bunkers to their guns, &c., looking like coal miners, and many physically weary from hard work in the bunkers. Manœuvres over and the ship paid off, Chief Engineer Gaudin and the writer were transferred to "Good Hope," a ship which with most other Belleville ships, lived out their useful lives, no longer the target of controversy. "Good Hope" was in continuous service until sunk at Coronel.

Subsequent to the commissioning of the "Spartiate" the writer was in charge of stoker firing parties lent to contractors for the acceptance trials of, among others, "Cressy," "Hogue" and "King Alfred," all Belleville ships, and all later credits and assets to the Royal Navy. One could not but observe, however, that while one went through her trials without a hitch, others by equally reputable firms took at least twice the time. The difference in each case was due to defective organisation, inexperience or even obstinacy.

Conclusion

The Belleville boiler having been banished by the committee, it is to the credit of the Admiralty that it remained determined upon water-tube boilers and carried on with experiments with various types. It adopted the Babcock boiler generally for capital ships and Yarrow or other small-tube boilers for smaller vessels. The Babcock, though heavier and occupying more space than the Belleville, gave good and reliable service through the first world war, but the small-tube boilers gave a good deal of anxiety, mainly as a result of one of the less well considered recommendations of the Committee of Enquiry. It was that all tubes must be straight. This insistence on straight tubes led to the two lower drums being "D shaped, and not cylindrical, from which arose the alarming and not always easily detected complaint known as "wrapperitis," which, together with leaky condensers, was a constant worry to Admiral Jellicoe in the Grand Fleet between 1914 and 1918.

Gaudin's direct appreciation of essentials, and clear statement of his opinions, regardless of the rank and importance of his hearers is illustrated by the following story. Detailed to explain to the First Lord—A. J. Balfour—the nature of this trouble, he was asked, "Who is responsible for this widespread defect ?" and replied at once, "You, sir." Lord Balfour, unruffled as ever, remarked that that was very interesting, but how did it come about ? "When you were Prime Minister, sir, you appointed a committee of people who knew nothing of naval boilers to investigate. Amongst their recommendations they said 'all boiler tubes must be straight.' Hence the 'D'-shaped drums and cracks at the junction of the tube plate and wrapper."

During the "Battle of the Boilers," it must be noted that the Admiralty was faced with the consideration of other engineering problems. The steam turbine was developing, and there were problems connected with the efficient burning and possible adoption of oil fuel. In both these matters it took a courageous and ultimately justified lead. Was it not equally courageous in adopting the Belleville boiler ? Was that boiler really as defective as it was made out to be ?

The writer does not think it was. He wonders, indeed, whether, had some other design been the first to be adopted, it, too, and equally, would have had to carry the odium of much prejudiced comment and the misfortune of much uninformed and unintelligent usage.

Plants for the Production of Anti-Knock Compounds

No. 1

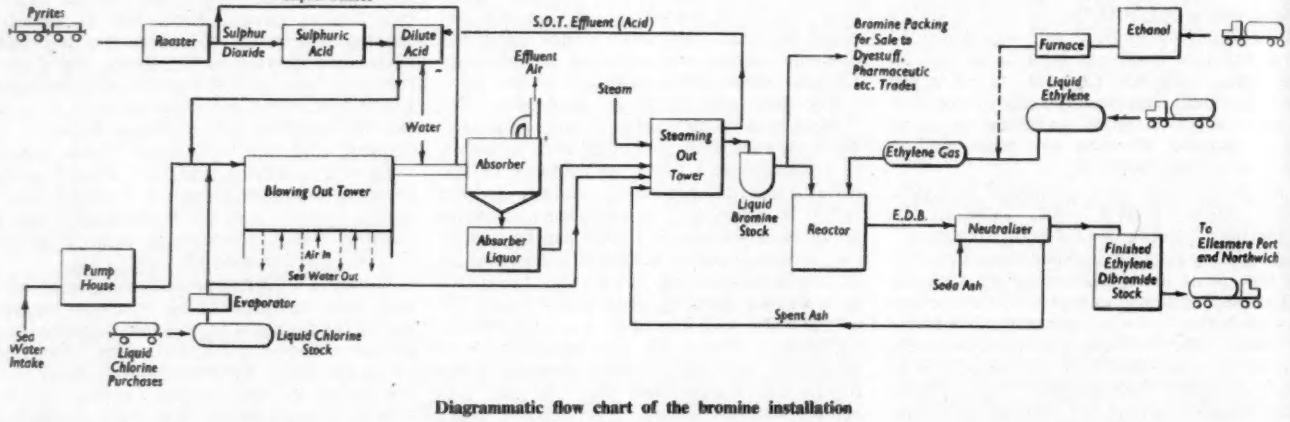
The Associated Ethyl Company, Ltd., after the war realised that the manufacturing capacity of its plant was insufficient to satisfy the demand of the world's markets for anti-knock compounds. Two-thirds of requirements had to be purchased from the dollar area and to save "hard" currency the company decided to increase its productive capacity. The scheme involved the building of a plant, in Anglesey, for the extraction of bromine from sea water and the construction of plants to produce sodium, ethyl chloride, ethylene dichloride and tetraethyl lead at Ellesmere Port.

As a result of the second world war the flow of trade was greatly changed due largely to the world being divided into sterling and dollar areas. Among those industries which have had to adapt themselves to the altered conditions is the oil industry, which, apart from other trading factors, had to reduce the dollar content of the oil to help to satisfy the demands for oil in the sterling area. One of the major changes effected was the revised policy towards refining, which resulted in a number of refineries being built in Great Britain and elsewhere in Europe so that crude oil need not necessarily be refined exclusively at a point relatively close to an oil field.

Oil is converted into a number of finished and marketable products in refineries by means of various physical and chemical processes and one of the most important end products is gasoline. It is one of the principal endeavours of the refineries to produce gasoline of the highest quality and one of its most important properties is its anti-knock qualities of which the octane number serves as a measure in association with the compression ratio of an engine. This ratio is a measure of the power of an engine and its efficiency, but any increase in the ratio requires a proportionate increase in the octane number so that the engine designer, apart from modifying the shape of the combustion chamber and adjusting the ignition timing, is limited by the octane number of the fuel. When operating under normal conditions the flame of the spark-ignited mixture travels smoothly at a known rate across the cylinders to provide energy, but should the compression ratio be too high for the gasoline used, then part of the mixture in the cylinder will explode prematurely. This is caused by radiation and the rapid expansion of the gas behind the flame front. This form of explosion or "knocking" causes the gases to become too hot so that much energy is lost as heat through the cylinder walls and power is lost.

Since the fuel itself sets a limit upon effecting any increase in engine efficiency by means of increasing the compression ratio, then the help of the oil chemist is necessary to produce fuels having a higher octane number. This was partly achieved by the development of the thermal cracking of the heavy ends from the distillation unit, while gasoline of an even higher number was produced by processes named polymerisation, hydrogenation, isomerisation, and alkylation. Straight run gasoline has an octane number of about 70, while that for cracked gasoline is about 82 and these fuels mixed together form a base stock to which high octane blending agents can be added and also another important ingredient, tetraethyl lead. By a suitable variation of the quantities of base stock, blending agents and tetraethyl lead, anti-knock values even higher than the iso-octane value of 100 are possible, such fuels being given a performance number.

This material tetraethyl lead, which plays such a highly important economic role in the oil industry, derives from the experiments made to prevent engine knock, which began in the first world war, and the material was first tested in 1921. However, it was found that another chemical compound was necessary to prevent fouling by lead oxide and eventually a halogen bearer, ethylene dibromide, was discovered which was miscible with tetraethyl lead and gasoline and acted as a scavenger by combining with tetraethyl lead during combustion. A mixture of tetraethyl lead and ethylene dibromide was added to gasoline to form aviation fuel and with the further addition of ethylene dichloride to form motor spirit. Although various and important improvements have taken place, since the introduction of tetraethyl lead, in refinery technique and equipment to provide gasoline having a greatly increased octane number, anti-knock compounds containing tetraethyl lead continue to be a most important factor in oil refinery production of high octane fuel.



Diagrammatic flow chart of the bromine installation

Plants for the Production of Anti-Knock Compounds

The availability of anti-knock compounds avoids the uneconomic development and use of special refinery equipment to produce high octane fuel and also permits the refineries to operate a flexible output programme. Many problems are involved in the production of tetraethyl lead and its associated components on a commercial scale and their solution required that special processes be evolved. In addition, due to the highly toxic nature of the material, elaborate safety equipment and manufacturing techniques had to be incorporated in the development of the processes.

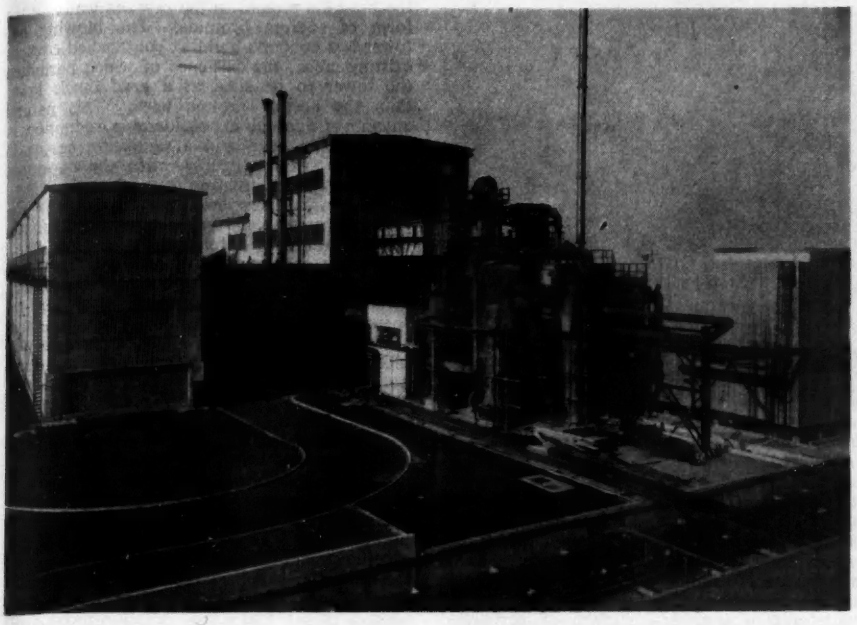
Among the manufacturing problems are: the production of high purity components; the avoidance of side reactions and maintenance of close control and the development of plant and ancillary equipment to ensure a high degree of safety. The increased demand for anti-knock compounds called for a supply of bromine which was beyond the capacity of the brine wells, so that it was necessary to turn to sea water as a source of supply. In 1925, a pilot plant to do this was installed in a Great Lakes steamer, converted for the purpose and renamed S.S. "Ethyl," and was operated for a time sufficient to establish that the method was commercially practical.

Tetraethyl lead was first sold in 1923 by the General Motors Chemical Corporation in Dayton, Ohio, and later the Ethyl Gasoline Corporation was formed for marketing anti-knock compounds containing tetraethyl lead under the trade name "Ethyl." Five years later the compounds were introduced in Great Britain and in 1931 the Ethyl Export Corporation was formed to supervise sales outside North America, where the use of the compounds had expanded more rapidly in aviation than motor fuels. At a later date, the Associated Ethyl Company, Ltd., was formed to take over the interests of the Ethyl Export Corporation and started operating on May 1, 1939. In 1936 a plant was built under licence by Ethyl G.m.b.H. in Germany and two years later a plant was constructed under licence for the French Government and leased to a company, now known as the Société de Produits Chimiques "Ethyl-Kuhlmann," jointly owned by the Associated Ethyl Company, Ltd., and Etablissements Kuhlmann. Ethyl-Kuhlmann, under licence from Dow Chemical Company, also built and operated a bromine plant.

A British T.E.L. plant was built under licence for the Air Ministry and also a bromine plant, built under licence from Dow Chemical Company, and both were leased to British Ethyl Corporation owned jointly by Ethyl Export Corporation and Imperial Chemical Industries, Ltd.

During the second world war the Alkali Division of the latter company operated the plants, which were acquired from the Ministry in 1945 by British Ethyl Corporation now 100 per cent owned by the Associated Ethyl Company, Ltd., and continued to do so until taken over by the Associated Ethyl Company, Ltd., on December 31, 1947.

The British plants served the markets in all countries except North America, France and Russia, and found that manufacturing capacity was insufficient to meet expanding demand, which necessitated the purchase of two-thirds of its requirements from the United States. It was essential to stop this drain on dollar reserves so that it was decided to build additional units, a decision which also involved the construction of ancillary units to supply component process materials. Both economic and practical



Sulphuric acid plant with building housing the flash roaster in the background and the pyrites store to the left

difficulties militated against choosing the sites for the new plants in the then main refinery areas and it was decided to build in Great Britain. In the final event a suitable site was found at Ellesmere Port in Cheshire for a plant to manufacture tetraethyl lead, sodium, ethyl chloride and ethylene dichloride, while an area at Amlwch on Anglesey was selected for the erection of a plant to extract bromine from sea water for the manufacture of ethylene dibromide. Construction of the Ellesmere Port plant commenced in February, 1951, and the Anglesey project two months later. The latter works began operations in November of last year while the Merseyside works started up in December last.

Before the war the European plants operated, mainly to improve aviation spirit, on the basis of a defence undertaking rather than as a commercial proposition, but since the war the situation has changed due to the greater world demand for higher octane gasoline. As already noted the new plants will, in common with the new refineries, effect a saving in dollar expenditure. The Associated Ethyl Company, Ltd., now exports its anti-knock compounds under the trade name of " Octel " to all countries except North America and France, the latter country being supplied with " Ethyl " from the Ethyl-Kuhlmann plant by Ethyl S.A., a fully-owned subsidiary of the Associated Ethyl Company, Ltd. The Associated Ethyl Company, Ltd., which now owns and operates four works, engineering, research and development and technical departments, has changed from being a distributive and advisory body to a manufacturing, sales and research organisation.

The Bromine Plant at Amlwch

The choice of Amlwch, Anglesey, for the erection of the bromine plant has been mentioned already, but before making such a selection a close study of conditions, particularly the temperature and bromine content of the sea water, was a primary essential. An examination of the flow of the Gulf Stream and plots of the constant bromine content lines around the shores of Great Britain indicated the effect of land formation upon the movement of the Gulf Stream and the bromine content. This dropped considerably in large bays and where the sea was diluted by estuarine water. By elimination of unsuitable areas, the search was narrowed down to suitable points and these were considered with due regard being paid to the qualifying conditions of maximum bromine content and temperature, accessibility to both road and rail systems, combined with being at a reasonable distance from the factory at Ellesmere Port. Again the area selected had to be capable of supplying a sufficient labour force. Another and perhaps the most important point in the final choice of the site within the area, was that the set of the shore currents should not be influenced by the rise and fall of the tide. This condition was absolutely essential since, for obvious reasons, the water, discharged from the plant after the bromine has been extracted, should not under any circumstances flow towards the intake end.

Having determined the general area satisfying the main requirements it remained to select a particular site and a rocky headland on the Anglesey coast close to Amlwch was decided upon and work commenced early in 1951. The rocky and rough ground presented problems in planning the layout of the plant but there were some natural resources, notably the existence of a small stream flowing through a break in the cliffs, which proved helpful in reducing both the capital cost involved and the working costs. We reproduce a diagrammatic chart showing the flow and the process stages.

The extraction of bromine from sea water is effected by acidification to reduce the pH value and treatment by chlorine gas to facilitate the release of the bromine which is present in the sea water as sodium bromide. To produce the ethylene dibromide required in the manufacture of the anti-knock compound, ethylene gas is bubbled through liquid bromine in reactors.

To supply the necessary quantities of sulphur dioxide and sulphuric acid, Simon-Carves, Ltd., has provided a plant in which sulphur dioxide is made by burning iron pyrites in the presence of air in a flash roaster. The iron pyrites is brought in by rail and unloaded by a 4·5-ton Heywood grabbing crane to a store. This is a steel portal frame structure with reinforced concrete retaining walls about 14ft 6in high and capable of holding 4000 tons of pyrites. During unloading operations the dust nuisance is minimised by the use of four counterbalanced curtains 14ft 6in square, which shield the trucks from the wind. From the store the pyrites is transferred by belt conveyor to the top of a dryer from the bottom of which an elevator raises the pyrites to a hopper feeding a ball mill. After being dried and ground the pyrites is passed to a flash roaster in which it spirals down and burns to reach a temperature of 1000 deg. Cent., giving sulphur dioxide and a residue of iron oxide. The gas is cooled in a waste heat boiler, then passed through a washing tower and afterwards partially dried in a mist precipitator before being finally dried in an acid dryer. Some of the sulphur dioxide is mixed with a proportion of air to give a concentration having a maximum of 7 per cent sulphur dioxide. This sulphur dioxide-air mixture is piped to the duct joining the blowing-out tower to the absorber building, where it is injected into the passing stream of bromine laden air. The remainder of the sulphur dioxide is converted, with the help of a catalyst, in a Monsanto oxidation unit into sulphur trioxide and then under controlled conditions is reacted with water to form sulphuric acid. This is diluted and then added in measured quantities to the sea water before it reaches the blowing-out tower, to reduce its pH number. Production of the plant is equivalent to about 50 tons of sulphuric acid per day. The sulphuric acid plant is illustrated, together with the building housing the flash roaster.

The chlorine required for the process is brought in as a liquid and unloaded by compressed air to one of eight tanks set on weigh scales which keep a check upon the quantity in the tank, which has a special fitting acting as a safeguard against overfilling. The tanks and the weighing mechanism are housed in a reinforced concrete frame structure, and there is provision for unloading two rail tankers simultaneously. From the tanks the chlorine is piped under pressure to a vessel in which it is vaporised by hot water and the resultant gas passes through a buffer vessel before proceeding direct to the process.

Liquid ethylene is imported from the Wilton works of Imperial Chemical Industries, Ltd., and

Rotary screens between the sea water discharge pond and the reservoir chamber, part of the pipe leading to the blowing-out tower can be seen and, in the background, the fans at the absorber building

Blowing-out tower showing sea water distribution boxes and pipework and the venturi duct to the absorber

stored in stainless steel tanks, having external insulation of "Onazote," and then it is passed through a steam-heated evaporator as required to produce ethylene gas, which is piped to two spheres, each fitted with a nylon diaphragm. This rises, when gas is admitted, to trigger a weighted switch which actuates a compressor and the gas, at a pressure up to 100 lb per square inch, passes through a buffer vessel on its way to a stock storage tank. In a locked area of the plant is the ethylene control station, housing instruments which record the temperature, pressure and the level in each tank. To provide against the possibility of a shortage of liquid ethylene due to road conditions or other causes, there is a standby plant, built by Head Wrightson Processes, Ltd., for making ethylene gas from ethanol. Here, ethanol vapour is heated and passed through a converter system in the presence of a catalyst and dehydrated to produce ethylene gas and water.

Description of Process

At the sea water intake a mass concrete cofferdam was erected to allow for the cutting of a tunnel 450ft in length from a natural inlet, to the pump well. The tunnel, which is 9ft in diameter and 3ft below the level of the lowest low water, has twin entrances fitted with shot blasted, zinc sprayed, bitumen painted, hand-operated, steel coarse screens, 10ft wide by 13ft high, behind which are wooden stop-logs for blanking off the entrances to allow repairs to be carried out to the tunnel and pump wells. A hand-operated overhead gantry is provided for handling the stop-logs and screens. The tunnel, which is designed for a flow of 320 cusecs, is concrete-lined and reinforced at the entrance to the pump shaft, where there are radiused corners and two roof supports of aero-dynamic shape, which help to direct the flow and avoid eddies. Since the site was on solid rock with ground level at 50ft above ordnance datum and the invert of the intake tunnel at 25ft below datum, it was necessary that the size of the pump shaft should be kept to a minimum to cut down capital expenditure on excavation work, while taking into consideration the running costs as influenced by the efficiency of the pumps.

The pumps fitted are two three-stage vertical axial flow Vickers-Gill units, each capable of delivering 30,000 gallons per minute against a total head of 63ft, and provision has been made in the excavation to take a third and larger pump designed to deliver 50,000 gallons per minute, all the pumps being supplied by Vickers-Armstrongs, Ltd. Slip-ring motors drive the pumps and automatic controls vary the speed of the pumps so as to maintain a constant supply of sea water at all states of the tide.

The pump shaft is concrete-lined and the pump and ancillary equipment, including a 15-ton crane, are housed in the reinforced concrete house which is built over the shaft. Model experiments were carried out to study the question of turbulence in the pump discharge pond, and as a result the pumps discharge through a 48in diameter bellmouth orifice, fitted with diffuser rings. The arrangement has resulted in the minimum of surface disturbance and exit loss from the pump, and the minimum impact against the screen filters through which the water flows to the reservoir chamber. These screens are of rotating drum pattern, each being of 16ft diameter, and consisting of a diaphragm plate and a peripheral surface of perforated plate. An external water spray keeps the surface of the screen clear of seaweed and other debris, which drops on to a trough and is discharged. Rubber seals are fitted to the screens.

After screening, the water enters the reservoir, by the way of a rectangular diffuser and then gravitates through a steel pipe to the blowing out tower. Our photograph shows the rotary screens leading to the sea water reservoir, and part of the pipe leading to the blowing out tower.

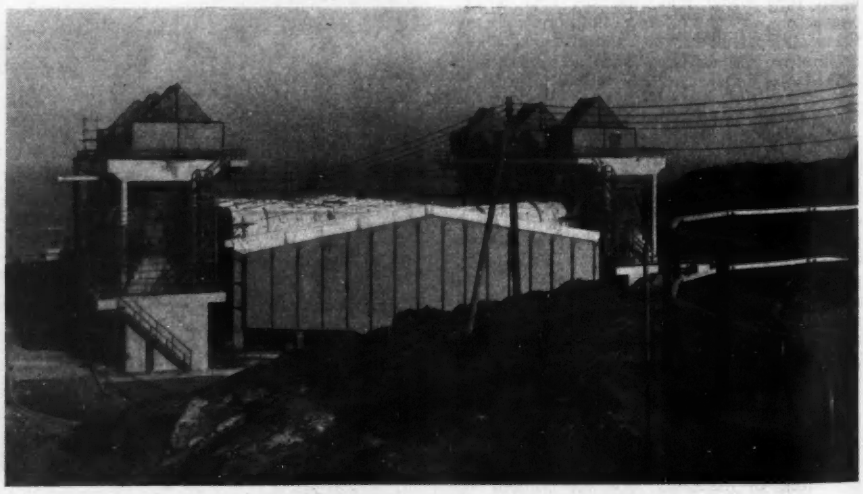
The pipe is carried on a reinforced concrete bridge, having an end span of 50ft, special provision being made for longitudinal movement of pipe or concrete. Fundamentally, the head of water in the reservoir above the pipe bears a constant relationship to the pressure drop through the system to control the pump delivery. Actually, this is done by means of a calibrated venturi meter forming part of the pipe, the recorded rate of flow being fed back to instruments which automatically control the speed of the pumps. As an additional check on flow, pitot tube traverses can be made.

The percentage of bromine which can be extracted from sea water increases enormously when its pH value is reduced. Therefore, on its way to the blowing out tower, measured quantities of dilute sulphuric acid are added to the sea water to reduce the pH value to within $\pm 0{\cdot}02$ of the required optimum value. Chlorine gas, evaporated from liquid chlorine by steam heating, is also added to the sea water to release the bromine present in the raw sea water in the form of sodium bromide. The blowing out tower is a concrete building constructed over an existing creek, the existence of which permitted the tower to be sited at a level much lower than the normal ground level. This natural advantage effected a considerable reduction in the pumping head and a significant saving in pumping costs, especially when the enormous amount of water involved is considered.

The tower is supported on fifty-two 4ft diameter concrete piers and is constructed on the flat slab technique developed by the consultants. It consists of a number of cells and having an open beam system, at the bottom, upon which ceramic rings are packed and through which the spent sea water is discharged. The treated water enters distribution boxes on the roof of the blowing-out tower and is then piped to a large number of concrete cells which are rubber lined, and random packed with "Raschig" rings. A thin film of water flows downwards over the surface presented by the vast number of rings and air drawn upwards by means of large exhaust fans, mounted on each side of the absorber building, extracts a high percentage of the bromine. The sea water effluent flows from the bottom of the blowing-out tower to join an existing stream which carries it out to sea. From the tower the bromine laden air passes through a large diameter steel duct, incorporating a large venturi pipe. Water and sulphur dioxide are added to produce a fine mist of hydro-bromic and sulphuric acids. The duct opens out at the absorber to ensure the efficient mixing of the sulphur dioxide and the bromine laden air. We illustrate the blowing-out tower and in the photograph can be seen the distribution boxes and piping on the roof of the tower and the duct leading to the absorber.

All the operations up to the absorber building are controlled from a laboratory. The process is fully automatic and fully instrumented, but samples are taken from points along the system for chemical tests to be made at intervals to act as a check upon the accurate functioning of the instruments.

Fairfield Shipbuilding and Engineering Company, Ltd., was responsible for the construction of the sea water pipeline, the large venturi and also for the fabricated steel portal trussed absorber building. This is lined with rubber, to protect the steelwork from the highly corrosive acid mists, and also acid-resisting brick. Within the absorber are arranged a system of water irrigated glass fibre filters, which condense the acid mist and the resulting liquor, which contains about 10 per cent bromine as hydrobromic acid, sulphuric acid and small quantities of hydrochloric acid, is collected in a trough. This directs the liquor to a collecting tank from where it is pumped to intermediate tanks before passing on to storage tanks. All the rubber lining work has been the responsibility of the Dunlop Rubber Company, Ltd., and has involved the application



The absorber building and the exhaust fans which are mounted on the switchgear houses and surmounted by spray catchers

of about 170 tons of compounded rubber over an area approximating 250,000 square feet.

On each side of the steel absorber are reinforced concrete structures built in three levels. The lower level houses the fan switchgear and also acts as the main support for the steel absorber, the second level provides the foundations for the exhaust fans, while the third level supports the spray catchers. The exhaust fans, already mentioned as being on either side of the absorber building, are six in number and were specially built by James Howden and Co., Ltd., and have rubber-lined casings and impellers. Each fan is fitted with spray catchers to ensure the minimum loss of acid mist. The fans are equipped with dampers and are controlled in groups of three. Both the blowing-out tower and the absorber are airtight. The absorber building is shown in our illustration, together with the six large fan units.

The primary acid liquor collected is fed continuously to two steaming out towers, housed in a brick-lined, mild-steel-framed building, packed with "Raschig" rings. At the base of the towers chlorine gas is injected to liberate the bromine from the hydrobromic acid and then the liberated bromine is subjected to a steam distillation process. The bromine produced leaves the top of the towers as a vapour and is condensed in a battery of condensers and the resulting liquid, a mixture of bromine and water, passes through separators and dryers. The water returns to the steaming out tower while the liquid bromine goes forward for conversion to ethylene dibromide. Although free from bromine the effluent from the steaming-out towers contains the sulphuric acid and some hydrochloric acid, which were mentioned earlier as being constituents of the acid liquor. It is pumped to the dilute acid tank where more sulphuric acid is added and the mixture is used to control the pH value of the sea water flowing through the main to the blowing-out tower.

To produce ethylene dibromide the liquid bromine, which has a high specific gravity of about 3·18, is fed continuously to one of a battery of reactors, mounted in the same building as the steaming-out towers, and then ethylene gas is bubbled through. The resulting reaction is exothermic and the large amount of heat generated is conducted away, at a controlled rate, by a sea water cooling system, to regulate the reaction so that there is a minimum loss of bromine and ethylene. The reactors consist of stoneware pots enclosed in concrete, then a lead membrane and more concrete and finally a mild steel shell. Each take about 3 tons of bromine and yields about 3·6 tons of ethylene dibromide. Fully instrumented control rooms record data concerning the process. The crude ethylene dibromide resulting from the reaction contains a small amount of impurities, such as hydrobromic acid, and these are removed in a neutraliser by means of adding sodium carbonate, while final separation is achieved by making use of the high density of the ethylene dibromide. Purified ethylene dibromide is piped to storage tanks ready for shipment by road or rail tankers to Ellesmere Port or Northwich, while the soda ash used in the neutraliser is recovered as sodium bromide and passed along to the steaming-out tower in recovering its bromine content.

Supply Services at Amlwch

A considerable quantity of steam is required for the bromine recovery process and this is partly raised in waste heat boilers, installed as part of the sulphuric acid plant, at a pressure of 250 lb per square inch and later reduced to 15 lb per square inch through a steam engine. Other sources for raising steam are Clarkson oil-fired thimble tube boilers which generate steam at 60 lb per square inch and this is brought down to 15 lb per square inch by a reducing valve. The steam at this pressure is fed into a common supply line for both process work and space heating.

To provide the necessary supplies of cooling water required for the sulphuric acid plant, the bromine reactors and the ethylene standby plant, two Sulzer borehole pumps, each rated at 1500 gallons per minute, have been installed in the sea water pump house and draw from the main intake sump. Also in the pump house is a standby emergency power unit which consists of a 130kW Brush generator driven by a 189 b.h.p. Mirrlees diesel engine, and which will enable one of the service water pumps to continue working in the event of a breakdown of the main electric supply and provide water for fire-fighting purposes. Fresh water for process work is supplied direct from local sources and there is a water tower which provides storage for 100,000 gallons in two concentric tanks, of 33ft 6in and 23ft 8in diameter, respectively, arranged around a central core 5ft in diameter which gives access to the main valve chambers.

Two Broomwade compressors provide the compressed air for the chlorine evaporator and the sulphuric acid plants, for instruments and other general purposes. Eductor pattern vacuum pumps develop the vacuum necessary for bromine removal in the packing area and for siphon operations in the bromine process.

The plant cannot economically generate its own electricity so supplies are taken from the Mersey and North Wales Electricity Board. Lines carry in 33kV which is reduced to 11kV in a substation outside the factory and two 11kV feeders supply the main switchboard, which in turn feeds three 11kV ring mains to area substations where the supplies are transformed to 3·3kV and 415V. It may be noted here that synchronous motors driving the exhaust fans at the absorber building were adopted to provide power factor control for the factory, which was a requirement for tariff purposes, and to overcome voltage drop trouble due to the long transmission lines.

Rail connection to the plant presented some difficulty and required an order from the Minister of Transport to permit the laying of a line to link up with the railway at Amlwch. This involved the demolition of some houses in the main street but fortunately the local authorities understood the necessity and welcomed the construction of the new factory and all it entailed. Those whose houses were demolished were rehoused in new houses built by the company for the purpose. The company has its own sidings at Amlwch which are connected to sidings in the works so that supplies of pyrites and chlorine can be brought in direct. Since the site was terraced with various units at different levels the sidings had to be built on an embankment which was constructed on the dry stone walling system, using stone already excavated. For handling the rail traffic there are two Ruston and Hornsby diesel locomotives.

Safety and security are the keynotes of the operational procedure throughout the plant and there is a special safety centre where all the necessary equipment is obtainable to combat mechanical hazards, the damage caused by the leakage of corrosive acids, the combustion of liquid ethylene and to ensure the safe handling of chlorine and bromine.

The civil engineering consultants for the plant were Maunsell Posford and Pavry in collaboration with Sir Alexander Gibb and Partners and the civil engineering contractor was Marples, Ridgeway and Partners.

(To be continued)

Fatigue Strength of Screw Threads*

EFFECT OF SPECIMEN SIZE AND HARDNESS OF NUT MATERIAL

By J. E. FIELD

A SERIES of investigations on the fatigue strengths of screw threads has recently been carried out at the Mechanical Engineering Research Laboratory. They included tests designed to determine and compare the fatigue strengths of ground threads of Unified form in diameters of ¾in and 2½in and of lathe-cut threads in diameters of ⅜in and ¾in, and to check the effect of pitch in the 2½in size; and tests to investigate the effect of using high tensile nuts as opposed to nuts of relatively low tensile strength. Details of the materials used in the tests are given in Table I.

Method of Test

The fatigue tests were carried out in machines of the Schenck "Pulsator" type, except for those on the ⅜in bolts, which were carried out in Haigh machines.

Each test was made between a lower and a higher limit in tension, and the load was applied through a nut, that being the type of loading usually applied in service to a properly tightened bolt. The nuts were all round, of diameter $2d$ and height d, where d=nominal bolt diameter. The minimum stress of the cycle was somewhat lower for the 2½in bolts than for the smaller sizes. This was because it is more difficult to induce high tightening stresses in large bolts, and the figure of 3 tons per square inch was chosen as a probable practical minimum. The minimum cycle stress for the smaller bolts was 4·46 tons per square inch. The maximum cycle stress was in all cases well below the 0·1 per cent proof stress of the material, and it is considered that this small difference in minimum stresses does not much affect the comparison of the results, which has been based on the range of pulsating tensile stress at the fatigue limit of the bolt and nut assembly. All the stresses quoted are

*Communication from the Mechanical Engineering Research Laboratory, East Kilbride, published by permission of the Director of Mechanical Engineering Research, D.S.I.R.

TABLE I—*Details of Bolt and Nut Materials*

Description of steel	M.E.R.L. reference mark	Heat treatment	Average tensile strength, tons/sq. inch	Average 0·1 per cent proof stress, tons/sq. inch	Average Brinell hardness number	Chemical composition								
						C	Si	S	P	Mn	Ni	Cr	Mo	Pb
3S1.—¾in bar for ¾in bolts	B	As drawn	38	31	200	0·33	0·19	0·04	0·02	0·64	—	—	—	—
3S1.—¾in bar for ¾in bolts	B	As drawn	39	30	205	0·38	0·17	0·03	0·02	0·76	—	—	—	—
3S1(N).— ¾in bar for ¾in nuts ...	F	As drawn	37	31	190	0·29	0·10	0·13	0·03	1·24	—	—	—	0·14
3S1(N).— 1¼in bar for ¾in nuts ...	F	As drawn	37	31	190	0·30	0·04	0·12	0·03	1·17	—	—	—	0·14
EN16T.—¾in bar for ¾in bolts ...	D	Oil-quenched from 850 deg. Cent. Tempered 610/620 deg. Cent. Air-cooled	60	47	295	0·36	0·19	0·04	0·03	1·67	0·20	0·19	0·25	—
EN16T.—¾in bar for ¾in bolts ...	D	Oil quenched from 850 deg. Cent. Tempered 610/620 deg. Cent. Air cooled	63	53	310	0·36	0·23	0·04	0·03	1·70	0·21	0·22	0·25	—
EN17T.—1½in bar for ¾in nuts ...	K	Oil-quenched from 850 deg. Cent. Tempered 620 deg. Cent. Air-cooled	66	56	330	0·36	0·17	0·03	0·03	1·55	—	—	0·43	—
Steel for 2½in bolts	X	Annealed	34	20†	145	0·46	0·28	0·05	0·02	0·46	—	0·18	—	—
Steel for 2½in nuts	Y	—	28	18†	130	0·14	0·07	0·03	0·05	0·57	0·11	—	—	—

† Yield stress. No definite yield was obtained with the other materials.

nominal values calculated on the cross-sectional area at the root of the bolt thread. Where fatigue failure occurred, it was always across the core of the bolt, near to the loaded face of the nut. The fatigue limits have all been based on an endurance of 10,000,000 cycles of stress.

Size Effect Tests

The fatigue strengths of ¾in and ¾in bolts with lathe-cut threads were determined as part of a research programme carried out in connection with the adoption of the new standard for the differences in tensile strength and pitch diameter ratio between these two sizes, it was found that the larger threads had a fatigue strength about 10 per cent lower than the smaller threads. This is an example of "size effect," which is associated with the different stress gradients at the points of maximum stress, obtained for the same maximum stress in different sizes of geometrically similar specimens. (As noted above, allowance had to be made for the lack of strict geometrical similarity between the 2½in and ¾in bolts.) Such stress gradients are

Table II—*Summary of Results of Fatigue Tests*

Size of thread	Method of production of bolt thread*	Bolt steel	Nut steel	Range of pulsating tensile stress at fatigue limit		
				Lb/sq. in	Tons/sq. in	Kg/sq. mm
¾—20 UN	Lathe-cut	B, 38 tons/sq. in	F, 37 tons/sq. in	17,000	7·6	12·0
¾—20 UN	Ground	D, 60 tons/sq. in	F, 37 tons/sq. in	27,500	12·3	19·4
¾—10 UNC	Lathe-cut	B, 39 tons/sq. in	F, 37 tons/sq. in	17,000	7·6	12·0
¾—10 UNC	Ground	B, 39 tons/sq. in	F, 37 tons/sq. in	16,500	7·4	11·7
¾—10 UNC	Ground	D, 63 tons/sq. in	F, 37 tons/sq. in	29,500	13·2	20·8
¾—10 UNC	Ground	D, 63 tons/sq. in	K, 66 tons/sq. in	28,500	12·7	20·0
64mm (2·52in) 6mm pitch, UN	Ground	X, 34 tons/sq. in	Y, 28 tons/sq. in	12,500†	5·6†	8·8†
64mm (2·52in) 4mm pitch, UN	Ground	X, 34 tons/sq. in	Y, 28 tons/sq. in	11,000†	5·0†	7·9†

* All nuts were finished by tapping.
† Corresponding loads were 30,900 lb for the 6mm pitch bolts and 30,200 lb for the 4mm pitch bolts.
The minimum stress of the cycle was 3 tons per square inch for these tests (64mm bolts). For all the other tests it was 4·46 tons per square inch or 10,000 lb per square inch.
Max. stress of cycle = range of pulsating stress + min. stress of cycle.

60 deg. Unified thread (B.S. 1580) form, which was found to compare favourably with the Whitworth form. The bolts were made from a steel (3S1) of about 39 tons per square inch tensile strength and assembled with nuts made from a free-cutting version (3S1(N)) of the same steel, having a tensile strength of 37 tons per square inch.

The results of these tests are given in Table II and it will be seen that there is no effect of size between the ¾in and ¾in diameters. This was also found approximately to be the case for bolts of a 63 tons per square inch steel (EN16T) with ground threads, for which results are quoted in Table II. The ¾in and ¾in bolts were, respectively, 20 t.p.i. and 10 t.p.i. and were geometrically similar.

A series of tests on ¾—10 UNC bolts in the 39 tons per square inch steel with ground threads, gave about the same result as for the lathe-cut threads. This does not mean that there will be no difference between ground and athe-cut threads in larger diameters. In fact, published work† seems to indicate that lathe-cut bolts of 3in diameter were, on the average, stronger in fatigue than the 2½in ground bolts tested at M.E.R.L. This is probably due partly to the beneficial effect of the cold-working occurring during the lathe-cutting operation, where the bolt material undergoes a degree of plastic deformation in the region of the tool point. Again, though careful grinding may obviate detectable surface cracking, there is still a possibility of residual tensile stresses in the surface.

The 2½in bolts were actually of 64mm (2·52in) major diameter, in two pitches of 4mm (0·158in, i.e. 6·35 t.p.i.) and 6mm (0·236in, i.e. 4·23 t.p.i.), respectively. The threads were of standard Unified form, to B.S. 1580 : 1953 (design form). The sizes were metric as Continental interests were involved, but the 6mm pitch threads correspond approximately to the 2½ by 4 t.p.i. size in the standard Unified Coarse series (2½—4 UNC). The steel used for these bolts was of 34 tons per square inch tensile strength and the nuts were made from a 28 tons per square inch steel.

The results of the fatigue tests on the 2½in bolts are given in Table II. The effect of pitch was slight. The nominal stress at the fatigue limit, calculated on the area of the bolt at the thread root, was slightly higher for the bolts of 6mm pitch, but since this core area was less than for the bolts of 4mm pitch, the actual load-carrying capacities of the two sets of bolts were about the same.

There was, however, a difference between the strengths of the ground thread bolts in the ¾in and 2½in diameters. After making allowances obtained in all cases of non-uniform stress distribution, i.e. in most practical cases.

Tests on Effect of Nut Material

The load distribution along the thread of a bolt and nut is non-uniform, the peak load occurring near the bearing face of the nut. The distribution would be improved and the peak load reduced by slight plastic deformation in the threads. This would lead to a higher fatigue strength of the assembly, provided that the plastic deformation was only local and did not lead to failure of the type occurring under static load. It has therefore become a generally accepted practice to use nuts of a somewhat softer material than the bolt, and there is a recommendation to this effect in B.S. 1083 (Table 10 and Note 4).

As, however, experimental evidence to support this practice seemed to be lacking, a short programme of tests was carried out to compare the fatigue strengths of high tensile ground-thread bolts, ¾—10 UNC, when assembled with high and with low tensile nuts, respectively. It will be seen from Table II that the difference was small, but in so far as it existed it supported the B.S. recommendation.

The threads used in these tests were accurately made. A greater difference than that found in the above tests would possibly be obtained with less accurate threads, where any "high spots" could more easily "bed down" with a softer than with a harder nut, so reducing the chances of local high stresses which might lead to fatigue failure.

It should be noted that these tests were all made on accurately produced threads. Less accurate production, whilst it might not lead to lower average fatigue strength for comparable bolt and nut assemblies, would probably give a much greater scatter of experimental results, with lower strength values in particular instances.

† Taylor, B., *Trans. Inst. Marine Engs.*, Volume 14, No. 12, December, 1952, "The Strength of Large Bolts Subjected to Cyclic Loading."

Copper Refinery in Northern Rhodesia

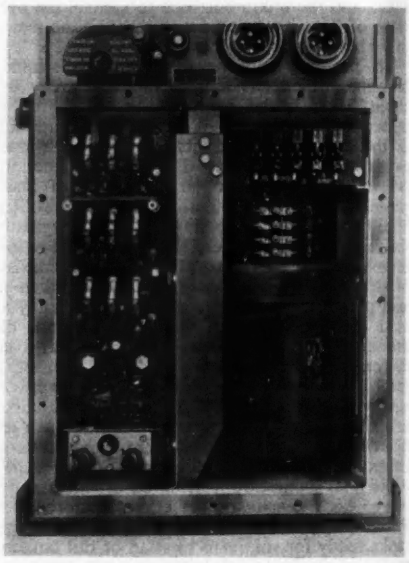
A £3,000,000 electrolytic copper refinery is to be constructed at Ndola, Northern Rhodesia, for Roan Antelope Copper Mines, Ltd. Its initial capacity will be between 55,000 and 60,000 long tons of electrolytic copper a year and the refinery will cater for the possibility of an eventual expansion to 110,000 long tons per annum, this expansion involving a further investment of £1,250,000 at present-day levels. Production is expected to begin in 1958 and the company is to enter into a long-term contract to supply the refinery with up to 60,000 long tons of blister copper a year. The refinery will be owned by a new company—Ndola Copper Refineries, Ltd.—the ordinary share capital of which will be taken up by Roan Antelope.

Flameproof Mining Drill Units

We learn that the flameproof mining drill units made by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17, have been modified to conform to the new safety requirements of the Ministry of Fuel and Power. The equipments concerned are the transformer unit "MU32" for two 50 c/s drills, and the frequency changer unit "MU12" for two 150 c/s drills. The protective arrangements now include an intrinsically safe circuit which (in the event of an earth fault) locks out the drill contactors until the fault has been removed and an intrinsically safe low-voltage pilot control circuit (carrying the Ministry of Fuel and Power Certificate No. T/RC53) for each drill. Over-current protection of each drill circuit is provided by an instantaneous latch-out magnetic relay and overload protection by a self-resetting thermal induction relay.

Both forms of equipment are designed for three-phase, 50 c/s supply circuits up to 650V. The "MU12" equipment, which is here illustrated with the covers removed, has a frequency-changer giving a three-phase, 125V output for 150 c/s drills. The "MU32" is identical in construction and appearance, except that, instead of the frequency-changer, there is a transformer with a three-phase, 125V secondary winding for 50 c/s drills. Both equipments are normally supplied for use with two drills, but they can be supplied for single-drill operation. They can be used singly or coupled to other gate-end boxes of the "MU" range.

Each unit is mounted on skids and consists of a welded steel flameproof enclosure divided by a flameproof barrier into an upper and a



Mining drill unit "MU12" for two 150-c/s drills. The frequency changer is mounted on the right of the lower compartment. In the "MU32" unit for 50-c/s drills a transformer replaces the frequency changer

lower compartment. The former contains a set of three-phase through busbars with a flameproof terminal plate at each end, and a triple-pole non-reversing isolator mechanically interlocked with the front cover of the lower compartment.

In the right-hand portion of the lower compartment the "MU12" unit, illustrated here, contains a frequency-changer which combines in a single machine the functions of a squirrel-cage motor suitable for a three-phase 50 c/s supply up to 650V and a generator with four sliprings to give a three-phase, 150V output for two 150 c/s drills up to 1 h.p. each. The neutral point is connected to the fourth slipring for the earth-leakage protection circuit. A triple-pole contactor controls the incoming supply to the frequency-changer, the contactor coil being connected to the contacts of two "MR10" control circuit relays (associated with the remote-control, intrinsically safe low-voltage pilot on earth continuity circuits), so that the frequency-

changer runs only when the drills are operating.

In the "MU32" unit the right-hand portion of the lower compartment is occupied by an air-cooled transformer which is rated for supplying two three-phase, 50 c/s, 125V drills up to 1½ h.p. each. The star point of the transformer is brought out for connection to the earth-leakage protection circuit.

The left-hand side of the lower compartment contains components common to both "MU32" and "MU12" units: they include three rewirable fuses for the protection of the transformer or the frequency-changer; a triple-pole contactor for each drill circuit; overcurrent and overload relays; two "MR10" relays; an "MR11" relay for earth leakage protection, embodied in an earth-leakage trip circuit and an intrinsically safe electrical lock-out circuit; a lamp for visual earth-leakage indication and a voltage transformer (with rewirable fuses) for the auxiliary supplies required by contactor coils and control circuits.

The remote-control and earth-continuity circuit provides remote control of the drills and prevents operation if the pilot core or the earth return between the drill and the mining unit is broken or develops a high resistance. It also interlocks the plugs electrically and prevents them from being withdrawn at power voltage. The remote-control circuit includes a relay with an operating coil having a closed-circuit secondary winding on the same core as the operative winding; in the event of a break in earth continuity this closed circuit secondary winding absorbs enough of the energy released during the collapse of the magnetic field to reduce any sparking that may take place, to a level at which the circuit is intrinsically safe.

An earth-leakage test switch is provided, to simulate an earth fault and prove whether the earth-leakage protection and lock-out circuits are in working order. This test switch is operated from outside the unit by a key which is also used for resetting the overcurrent relay.

Incoming cable facilities consist of either a trifurcating box or a flit-plug with an adaptor. For the outgoing cable supplying each drill there is a 30A restrained four-pin plug and socket, as illustrated.

Self-Compensating Infra-Red Spectrometer

THE high cost of infra-red spectrometry equipment currently available, which was developed for research purposes, has tended to limit the most complete use of the technique in industry. There has consequently arisen a demand for a high resolution dispersing instrument covering a specific range of wavelengths at a price which would enable it to be used for routine analysis or process control on the widest possible scale. The availability of the Merton-N.P.L. diffraction gratings has enabled this need to be met, and a spectrometer covering the important 2·8 to 3·8μ region is the first of a series of such instruments to be introduced by The Mervyn Sound and Vision Company, Ltd., St. John's, Woking, Surrey, each covering a specific region of the infra-red spectrum. The instrument can be used with a single beam for identifying particular compounds, and it has a special system which enables the instrument to simulate double beam operation and indicate transmissions directly. The overall stability of the instrument is such that it is stated to be eminently suitable for use as a process controller when the grating is locked at one predetermined setting.

The spectrometer source is a Nernst Glower, gas starting and choke stabilised, the light output being interrupted 800 times per second. The monochromator consists of a Merton-N.P.L. grating of 8000 lines per inch blazed for 3μ with a filter to absorb unwanted orders, and a lead selenide cell is used as a detector. A high-gain amplifier followed by a special correlation detector and an adjustable integrator network combines adequate sensitivity with a control of signal-to-noise ratio at the output.

A very high order of overall long-term and short-term stability for quantitative measurement, comparable with that of a null method balanced double beam spectrometer is obtained on this instrument by means of a system of compensation developed by the company. By this system the light output from the source is continuously monitored through the detector and the gain of the amplifier is adjusted automatically so that variations in output of the source, the sensitivity of the detector or drifts in the amplifier characteristics appear as negligible variations in the output.

This property is of special importance in view of the stress that is now being laid upon quantitative measurements of absorption, and it makes the instrument suitable for the automatic control of industrial processes.

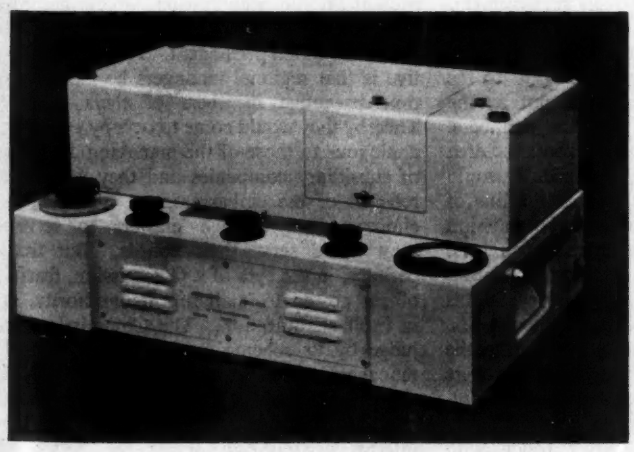
Another detail of the instrument is a continuously adjustable cam, by means of which the compensated gain level of the amplifier is automatically corrected to allow for the wavelength characteristics of the source, the filter and the detector. If desired, it may be set to allow for any non-linear absorption in the cell. This characteristic, to a very large extent, removes the necessity normal to single beam spectrometers of having to apply a correction to the final record, the correction first having been obtained by running through the spectrum without a sample *in situ*, and plotting from the resultant curve.

Controls and Facilities.—The main control is a dial calibrated directly in wavelengths. This may be operated manually, set at a fixed setting, or may be rotated by a synchronous motor, to give a continuous scan. The scan is unidirectional and the output is reduced to zero during the flyback in order to remove ambiguity. The output is presented on a meter calibrated directly in percentage transmission. A pen recorder may be connected externally via a jack.

There are three additional controls. One for bandwidth, one for meter "zeroing," and one as a fine output control. Large changes of gain, which may be needed to cope with abnormally opaque samples, are obtained by varying the light attenuator in the reference light path. The control knob for this is situated inside the sample compartment.

Facilities are provided for evacuating the monochromator or for filling it with a suitable gas. The sample compartment can be adapted to take absorption cells of any kind with which the user may be familiar. Alternatively any normal type of cell can be supplied by the company.

This particular instrument can be used for analysis or control of any compound having absorption bands within its range. Such compounds, occur in many industries including the petroleum industry, manufacture of plastics, paints and resins; production of detergents; explosive manufacture; preparation of pharmaceutical products and other therapeutic substances; and the analysis of heavy water.



Spectrometer using the Merton-N.P.L. diffraction grating and operating in the 3μ range

Measurement of Depth of Case in Case-Hardened Steels

A CONTRIBUTION to the vexed question of the best method of ascertaining the depth of case in a case-hardened steel has been published by H. Müller.* He experimented with four case-hardening steels having the approximate compositions given below:

	A	B	C	D
Carbon, per cent	0·15	0·15	0·20	0·18
Silicon, per cent	<0·4	0·25	0·25	0·25
Manganese, per cent	0·5	0·4	1·2	0·5
Chromium, per cent	—	—	1·2	2·0
Nickel, per cent	—	—	—	2·0
Diameter, millimetres	8	20	20	20
Quenched in	Water		Oil	

These four steels were carburised together to a depth of about 1mm and then each steel underwent fifteen different heat-treatments designed to produce hardness-depth curves of the greatest possible variety. After the final hardening, the specimens were broken in a testing machine by a bending stress applied at a constant rate. The depth of case in each of the sixty specimens was ascertained by five different methods which were considered critically and compared with one another. The estimates of depth were made by examination of the appearance of the fracture; by macroscopic examination of a ground section after etching it with 5 or 10 per cent solution of nitric acid in alcohol; by microscopic examination of a ground and polished section etched with 3 per cent solution of nitric acid in alcohol; by a scratch test, and by determination of the form of the hardness-depth curve. For the first two, only a magnifying glass was needed. The others required special apparatus, viz., a metallurgical microscope or a scratch-test machine or a Vickers hardness testing machine. The following conclusions were drawn from the results:—

(1) The microscopical method of estimating case depth is not, in many instances, entirely practicable, and for works operations it is a time-consuming process.

(2) The depth ascertained by the scratch method is in general appreciably greater than the depth measured by other methods. The case depth, according to the scratch method, corresponds to no definite point on the hardness-depth curve, and gives no satisfactory evaluation of the practically important or useful part of the hardness curve.

(3) The hardness-depth curve alone supplies clearly determinable hardness-depth values in the upper range of hardness, i.e. to a hardness of about 500 Vickers.

(4) The values of depth of case determined from the appearance of the fracture and from macroscopical examination of a ground and etched section fall within the same order of magnitude and give similar scatter. There is reasonably good correlation between the case depth determined by these methods and the depth at which the Vickers diamond hardness falls to 500. In about 70 per cent of the specimens the depth of case according to the simple fracture test was in agreement with the hardness-depth curve for a hardness of 500 Vickers to within an accuracy of ±0·1mm.

These studies have made it clear that there is close correspondence between the results of testing by appearance of the fracture, and by hardness-depth curves down to the practically useful hardness value of about 500 Vickers, provided that the heat-treatment and valuation are always carried out under similar conditions. It is implied that for industrial use, as a works test, the fracture method is the most suitable. The author of the paper, however, recommends that in doubtful cases, and for individual check, the hardness-depth curve should be determined.

* *Archiv für das Eisenhüttenwesen*, March/April, 1954, page 125.

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REORGANISING THE RAILWAYS

Bad organisation, because it makes unreasonable demands upon the toleration and good-nature of human beings, inevitably contains the seeds of discord. But in the running of any business much more depends upon the people involved than upon the details of the organisation. Given high morale and good team work a firm can still prove efficient even though its organisation is defective. Nor does effective organisation inevitably lead to efficiency. It merely makes it easier to achieve. Thus, in examining the Railways Reorganisation Scheme, published as a White Paper last week and noticed in the pages of our last issue, it is quite impossible to say whether the organisation proposed in that document will or will not lead to more efficient operation of the railways. All that can be said is that, because the scheme provides for effective decentralisation of day-to-day control, it seems capable of breeding more efficient operation, if only through the stimulation, as between the railway regions, of a spirit of emulation. But even that remark needs qualification. For within the organisation set up by the Transport Act of 1947 it would still have been possible to decentralise. A deliberate policy of centralisation was at first chosen because if the original group railways were ever to recognise their merger into a single entity then for a time it was essential that authority, even for quite detailed matters, should be centralised. A similar decision on policy, it is worth while noting, was taken as soon as the railway companies were merged into groups in 1921. Delegation of responsibility followed as individual companies grew to recognise the authority of the group, and the process of decentralisation was still going on as late as 1939. No doubt under the Transport Commission and the Railway Executive, responsibility would similarly have been gradually delegated to the Regions. There was nothing in the organisational scheme to prevent that delegation.

In one way, however, the organisation set up by the Transport Act of 1947 was defective. The Commission exercised its central authority over the railways through the Railway Executive. But the members of the latter were appointed not by the Commission, but by the Minister. That the arrangement led to difficulties can be inferred from a pointed, not to say barbed, sentence in the White Paper: "The experience of the Commission between 1948 and 1953 has shown how essential it is that the authority of the Commission in the scheme of organisation should be absolute." Unfortunately, or so it seems to us, that experience was so painful that in suggesting a new organisation for the railways the Commission proposes a scheme in one respect just as defective. At present, under the "Interim" organisation created as soon as the Railway Executive was abolished by the Act of 1953 the Commission is responsible for policy and general direction; but authority has been delegated to a Chief Regional Manager in each Region for day-to-day management. Basically the proposed organisation is the same. But there is the major exception that for each Region an area board is to be appointed (by the Commission, not by the Minister) composed of part-time members. It is these bodies that are to become the area authorities. In these circumstances, it would be a reasonable expectation that the line of authority should run from the Commission through the boards to the regional managers. In fact, however, the Commission, no doubt, painfully conscious of past history, seems wary of giving full authority to the boards. The scheme provides that, in addition to the chairmen of the boards, the regional managers shall attend regular meetings of the Commission, and that those managers shall maintain in the future the direct touch with officials of the Commission that has been built up under the interim organisation. Thus, the boards, made up of part-time members, are to be responsible for their areas through managers who will not only know more than they about their areas, but will also be more directly in touch with the Commission and better aware of its policies. The boards, in fact (even though at least one member of each will also be a member of the Commission), look far more like advisory than executive bodies; yet they are to have executive powers. In principle, the authority of a manager is to be derived from the area board. In fact, it may well prove to come directly from the Commission. Thus, though the organisation has been devised by the Commission with exactly the opposite purpose, we cannot help feeling that "by the establishment of boards as the area authorities" upon this plan "an element productive of friction and lack of cohesion may be introduced."

Flexibility in an organisation is a very desirable quality. No attempt, for example, should be made to define very rigidly where the responsibility of an individual begins or ends, lest something should turn out to be the responsibility of none! But if boundaries of responsibility are best left ill-defined it is essential that the line of authority should be well marked. For no man can serve two masters. But a regional manager under the Commission's scheme might well find he was attempting to do so. For what should he do if he knows that instructions received from his board conflict with the Commission's policy? Should he follow the instructions of the board, whose executive official he is, or should he endeavour to interpret the policy of the Commission to which he owes his appointment and through whose command he has become directly aware of the details of that policy? It is not, perhaps, a situation likely to arise; but the possibility that it might occur would be, in itself, embarrassing and frustrating. Three alternatives seem open to correct this defect. To the first, that each board should decide upon its own authority whether or not its manager should regularly attend meetings of the Commission and continue to maintain direct contact with Commission officials, the Commission would, no doubt, object as likely to give too much independence to the boards. To the second, politicians might object as concentrating control too much towards the centre. It is that the present interim organisation, which, according to the White Paper is "working well," should be made permanent. A third alternative is that regional managers be made full-time executive members of their boards. Thereby they would come to occupy positions analogous to those of the managing directors of subsidiary companies and they would be relieved of the embarrassment of trying to choose which of two masters to serve; they would serve their boards. But that, perhaps, in the eyes of a Commission, fearful of its power to maintain its authority, is in itself an objection. The Commission, to judge by its scheme, would prefer regional managers to remain answerable—in fact, if not in principle—to itself. Under these circumstances, to give permanence to the interim organisation seems the better of these alternatives. Would it really perpetuate too much centralisation? Might

it not encourage exactly the opposite consequence? For a Commission, fearful for its authority, would surely be willing to delegate more responsibility to its paid servants, the regional managers, than to boards of part-time and almost independent members.

TRAINING OF SUPERVISORS

Attention has been drawn on more than one occasion to the value of systematic training of supervisors, and the last war with its necessity for a large increase in industrial capacity of a specialised nature gave further emphasis to the subject. Even before the war technical colleges had taken up the subject, and after it came the important development of training within industry which was taken up enthusiastically by a number of firms. But long before all this had transpired there was a realisation that something in the direction of better training of staff was needed, and we might perhaps instance the case of the Royal Ordnance Factories, Woolwich, where so-called efficiency meetings were held at regular intervals for the supervisory staff to discuss different branches of the organisation and the many problems arising. For example, an evening might be devoted to costing and after the cost accountant had briefly explained his place in the hierarchy, the chairman, or a member of the upper staff, would invite a full and free discussion, with the result that at the close of the meeting the average foreman would appreciate, perhaps for the first time, how useful a good costing system might be to him. One advantage of such meetings was that no one felt he was being sent back to school, a real danger at the present time. Too often in early days the old Latin proverb, *stultus labor est ineptiarum* was subscribed to whole-heartedly, but though it might apply to some walks of life, the study of detail is often of paramount importance in industry as it may eventually have a profound effect on general economy. This consideration is often lost sight of by the supervisor and here training can be very valuable in explaining how both the broad outlook and the investigation of apparent trifles should always receive attention. The Ministry of Labour and National Service, while appreciating the way in which training has already been developed, recently felt it would be advisable to investigate the whole matter, making use of all available information, and a special committee was set up for this purpose, its report being now before us.

Very wisely a broad definition of "supervisor" was adopted by the committee. Generally speaking it indicates the individual in that somewhat unenviable position between the upper millstone of management and the nether one of the operator, while those on the still lower plane who are looking for advancement and may be suitable are not neglected. Similarly broad is the definition of training, for it is intended to embrace everything "calculated to make a supervisor better at his job." It is essential that foremen be given information about the firm's organisation and policy and this can best be effected by the management itself taking an interest in the matter, and arranging appropriate lectures and discussions, a member of the upper staff being ready to answer questions. Indeed, the departmental manager should recognise his responsibility for making his own contribution towards the training of his staff. It cannot be stressed too emphatically that unless the status of a foreman is very definitely determined he must always be at a disadvantage. It should also be clearly understood that he is part of the management and accordingly he must be taken into its confidence. When we come to the question of actual training it is dangerous to generalise, as each industry has its different problems, even though there may be basic principles of supervision common to all industries. Such principles can be taught. But the teaching should be coupled with learning by practical experience, and having the mind developed by a study of some of the problems. Again, the foreman should be given some knowledge of industrial agreements affecting his work and industrial relations generally. These subjects can be taught. Another important consideration in his training is the point at which it should begin, and there is much to be said for its taking place even before his appointment as a supervisor. This choice may enable a firm to select the most suitable man, but it is wise only to train those men who stand a reasonable chance of promotion, or a degree of frustration may be engendered. It would be well if the management were more alive, as is, indeed, often the case, to the value of a good example, for the attitude of a supervisor to those in his charge is bound to be influenced by the treatment he receives from his own superiors. Future recruitment of staff should always be kept in mind when a scheme of training for a particular industry is being evolved.

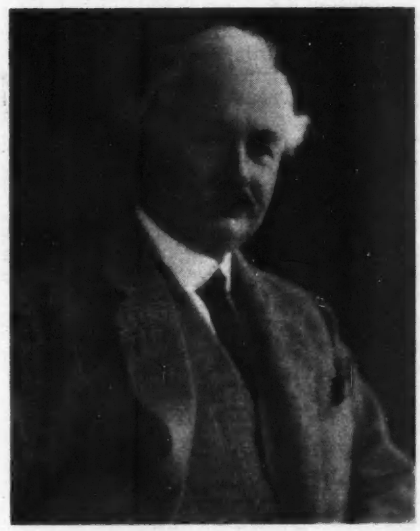
The Ministry has done well to investigate this subject, and give concrete examples of what is being done, and directors and managers of engineering factories will do well to pay attention to the findings of the committee. Even if there are no immediate and direct results nothing but good can follow, for the committee represented a variety of institutes and interests, and by devoting so much time to the subject each member of it must have widened his own outlook. It should always be borne in mind that until comparatively recently the foreman was monarch of all he surveyed in his little kingdom, but *tempora mutantur et nos mutamur in illis*, the foreman himself is changed by the changes encountered. With functional organisation so much to the fore he may sometimes feel frustrated, whereas in reality the importance of his position is by no means lessened; rather he can now concentrate on the work which is more legitimately his, and leave the trimmings to others. Much heartburning might have been avoided if before the inception of functional management in a factory the foreman had been taken round some works where it was in successful operation. Exchange visits are a valuable side of supervisor training. There will always be the danger that the training may degenerate into "spoon feeding," but we are convinced it is essential that each supervisor should be trained to think and act for himself. Even if we have some way to go before finality is reached, we suggest there is still much for the higher officials to do. Indeed, we might even go further and suggest that a training for the industrialist himself and the works director might well prove valuable.

Obituary

SIR ERNEST PETTER

For many years up to his retirement in 1937, Sir Ernest Petter occupied a prominent place in the British oil engine industry. We regret having to record his death, which occurred, in the early hours of last Sunday, July 18th, at Bywell, New Milton, Hants, at the age of eighty-one.

Ernest Willoughby Petter, who was born in 1873, was one of the sons of the late James B. Petter, of Yeovil, Somerset. He was educated at Mount Radford School, Exeter. When he left school, he served a five-year apprenticeship with the family engineering concern of James B. Petter and Sons, Nautilus Works, Yeovil, which at the time was concentrating upon the development of oil and petrol engines. Soon after his apprenticeship was completed, Ernest



Sir Ernest Petter

Petter, with his twin brother Percival, took a particular interest in the building of an "oil-motor carriage," which was undertaken by his firm in conjunction with Hill and Boll, carriage builders, of Yeovil. The power unit was a 1 h.p. oil engine, and, at the time of its appearance, we recorded that the total weight of the carriage, "with oil and water complete," was 9 cwt, of which "the engine proper, including fly-wheel and side bars," weighed 120 lb. With two people aboard, and travelling on level road, a speed of 10 miles an hour was claimed. In a description of the engine, we said that it started in ten minutes, ran without attention, and was "almost noiseless."

In 1897, Ernest Petter became a partner in the family firm, and a few years later, with his brother, P. W. Petter, reorganised the business which was thenceforward known as Petters, Ltd. It continued at Yeovil until 1937, and made many notable contributions to oil and petrol engine development in this country. Sir Ernest was joint managing director and subsequently chairman of the company. He was also managing director of Vickers Petters, Ltd., of Ipswich, in the formation of which company in 1919 he took a leading part. In 1938, the oil engine

assets of Petters, Ltd., were acquired by Brush Electrical Engineering Company, Ltd., Loughborough, and the manufacture of the firm's engines at Yeovil was terminated. Just prior to that event, Sir Ernest relinquished the chairmanship of the company, and for some years resided in British Columbia.

In addition to the demands of his business, Sir Ernest shared for several years in the work of the British Engineers' Association, of which he was president from 1923 to 1925. He was also a member of the executive of the Federation of British Industries. For some years, too, he took an active part in politics, and produced a number of pamphlets on industrial and economic subjects. Sir Ernest, whose knighthood was conferred in 1925, was elected an associate member of the Institution of Mechanical Engineers in 1900, and was promoted to full membership four years later. Subsequently, he was for a time a vice-president of the Institution.

EDWARD THOMPSON

We record with regret the death of Mr. Edward Thompson, of 61, Westgate Bay Avenue, Westgate, Kent, which occurred at Brymbo, Wrexham, on July 15th. Mr. Thompson, who was seventy-three, was formerly Chief Mechanical Engineer of the London and North-Eastern Railway.

Edward Thompson was born at Marlborough, on June 25, 1881, and was educated at Marlborough College and at Pembroke College, Cambridge, where he gained a Mechanical Science Tripos in 1902. In the following year he became a premium pupil in the works of Beyer Peacock and Co., Ltd., Manchester, and thereafter spent a year or so in the running department of the old Midland Railway at Derby, under the late

Edward Thompson

Sir Cecil Paget, who was then works manager. Mr. Thompson left the Midland in 1905 to join the staff of the Royal Arsenal at Woolwich, but he resumed his railway career a year later when he was appointed to a position in the running department of the North-Eastern Railway at Hull. From there, he went to Gateshead in 1909 to become assistant divisional locomotive superintendent of the North-Eastern. Three years later, Mr. Thompson transferred to the Great Northern Railway as carriage and wagon superintendent at Doncaster. His career with the G.N.R. was interrupted by the first world war, during which he served in France on the headquarters staff of the Director-General of Transportation, being twice mentioned in dispatches and awarded the O.B.E. (Military Division).

Mr. Thompson resumed his service with the Great Northern Railway in 1919, and in the following year returned to the North-Eastern Railway as carriage and wagon works manager at York. With the grouping of the railways and the formation of the London and North-Eastern Railway Company in 1923, Mr. Thompson became area carriage and wagon works manager for the whole of the north-eastern area. His next appointment was that of assistant mechanical engineer at Stratford in 1927, being promoted three years later to the position of mechanical engineer. Mr. Thompson went back again to the north-eastern area of the L.N.E.R. in 1934 as mechanical engineer, and in 1939 moved to the southern area (western section) as mechanical engineer. On the death of Sir Nigel Gresley in 1941, Mr. Thompson was appointed Chief Mechanical Engineer of the L.N.E.R., from which position he retired in June, 1946. Just before his retirement, an L.N.E.R. class "A2" "Pacific," which was the 2000th locomotive to be built at the Doncaster works, was named "Edward Thompson" in his honour. Mr. Thompson had been a member of the Institution of Mechanical Engineers since 1929.

T. F. LISTER

We regret to learn that Mr. T. F. Lister, chairman of Hackbridge and Hewittic Electric Company, died on July 13th, at the age of seventy-one. After starting his engineering training at Halifax Technical School, he started work at a small engineering firm in Yorkshire in 1898. Three years later he joined Ferranti, Ltd., and after a few months at Hollinwood was transferred to the contracts department of the company's London office. When this office was closed down in 1904, he joined The General Electric Company at Queen Victoria Street.

In 1905, Mr. Lister joined the British Westinghouse Company, which later became Metropolitan-Vickers Electrical Company, Ltd. He remained there for twenty years, and during that time he gained valuable experience in the large machine division, switchgear, transformer and meter departments. During the first world war he had charge of the deep-sea mining department and the magneto department. After the war, when a main production department was started covering the whole of the Trafford Park Works, Mr. Lister was appointed first superintendent, a position he held until 1925, when he left Trafford Park to take up the position of manager of the Hackbridge Electric Construction Company at Walton-on-Thames.

In 1926 he was appointed manager also to the Hewittic Electric Company, Ltd., becoming director of both companies in 1931. He became managing director of these two companies and the New Switchgear Construction Company, Ltd., in 1944, and was appointed chairman and managing director in 1946. In 1947–48 he was made chairman and managing director of the newly amalgamated group of companies under the title of Hackbridge and Hewittic Electric Company, Ltd. He retired from the position of managing director in March, 1954, but remained chairman of the company.

One of his many interests was the British Electrical and Allied Manufacturers' Association, and he was chairman of its council in 1951 and 1952. He was a governor of Brooklands Technical College, Weybridge.

Literature

Grosse Ingenieure. By Conrad Matschoss. Fourth Edition. Germany: J. F. Lehmanns Verlag, München, 15. Price DM. 20.

It has been said that there is no Plutarch for the men of science and it is, of course, true. We must remember, however, that Plutarch, the most popular of all Greek authors, was a philosopher and moralist as well as the greatest biographical writer of antiquity. Philosophy which does not lead to practical wisdom is vain and we are glad to find, among certain writers of scientific biography, something of the same spirit which informs Plutarch, whose writings reflect the personality of the men with whom he deals so faithfully. In the book now before us, Conrad Matschoss has produced an example of biographical writing in which the spirit of the philosopher informs the findings of the careful historian. We quote the following translation of his Foreword :—

"Technology is not limited by frontiers and is not the work of any one individual; the threads pass backwards and forwards from nation to nation and from development to development. The roots of our modern practice go back to the beginning of time."

Written by Professor Matschoss in September, 1937, these words give the key to his book, which, printed in German language, contains, along with an ably condensed account of the engineering science of the ancients, a collection of brief biographies of engineers and craftsmen from the thirteenth century onwards. The collection is not, of course, complete, but it has certainly been composed with a view to rendering the picture as inclusive and well balanced as is practicable in the limits of 378 pages. The fifty-five illustrations are of particular interest, among them the reproduction of a portrait—at the University of Marburg—of Denis Papin.

It implies no reflection upon Matschoss if we point out that there is much of major importance which he omits. This is rather to emphasise the vastness of the subject than to suggest neglect on the part of the learned author. We would note, in illustration of the omissions, that while there is an admirable account of Johannes Gutenberg and his work, there is no mention of the momentous development, in the early years of the nineteenth century, of the continuous paper-making machine, a development which owed a great deal to the labours of the British engineer Bryan Donkin. A German pioneer not mentioned is Georg Lenkensperger of Munich, who first described the pivoted stub-axle with articulated control rod connecting the two axles. Leonhard Euler is not referred to and it can certainly be maintained that he has an importance in the history of engineering science which puts him very high among "Grosse Ingenieure." Georg Simon Ohm is also among those not mentioned, though the writer of this review is glad to record—from personal observation—that in spite of the bomb havoc in Cologne, Ohm's memorial is still to be found on a wall of the school, in the Marzellen-Str., where he wrote the famous pamphlet containing the law now known by his name. On the pioneers of the internal combustion engine, among those to whom reference is omitted are Barber, Lebon d'Humbersin, Samuel Brown, Barsanti, Brayton, Beau de Rochas, Capitaine and Akroyd Stuart. It is to be observed, however, that the fine international spirit reflected by the biographies included is equally apparent when we come to enumerate those omitted, a circumstance which intensifies not only one's respect for the author, but the significance of his book.

The literature of technology is already stupendous in quantity and as is common to all kinds of history, unequal in merit. Through the works of Vitruvius, Heron of Alexandria, Leonardo da Vinci, Georgius Agricola, Jacques Beeson, Agostino Ramelli and others, we are made the more humble by realising the extent of our indebtedness to the labours of those pioneers—known and unknown—who laid the foundations upon which mechanical engineering science has been built up. In more recent times, the work in England of such as Rhys Jenkins and H. W. Dickinson has been marked not only by wide technical knowledge, but by the use of massive facilities for reference as well as intense application devoted to ascertaining the truth. That Conrad Matschoss stands high among the historians of technology has long been known, and in this book we salute a writer who, in striving to do honour to the great engineers of times gone by, encourages all engineers not only by the examples which he illumines, but by showing how the rare seeds of mechanical genius are scattered over all nations so that they may be productive of blessings shared by all mankind.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SIR CHARLES PARSONS

SIR,—My letter published in your issue of June 25th, referred to by Sir Claude Gibb in his letter in your issue of July 9th, was intended to strike a fair and reasonable balance between the achievements of Sir Charles Parsons and Dr. S. Z. de Ferranti. The fact that Ferranti's contribution to steam power engineering was a lesser one than that of Parsons makes it not less important to give Ferranti the credit which is his due.

Other facts must be adduced in striking a fair balance of credit : for example, single stage regenerative feed heating was introduced many years before Parsons and Ferranti became active in this line of country. The jacketing of steam engine cylinders was introduced by Watt and was elaborated by E. A. Cowper, who also introduced steam-to-steam reheating between cylinders. Cowper is credited with having achieved the lowest steam consumption relative to power output of any of the marine propulsion engineers of his day, and he lectured on the various aspects of this matter with great power and lucidity to the Institution of Civil Engineers on January 17, 1884. Sir Claude Gibb mentions Parsons as having referred to the same idea in relation to his steam turbine in his patent No. 5074, but nobody could claim that it was then an important novelty ; surely it was as obvious a thing to do with a turbine cylinder as with a piston cylinder.

Ferranti took out, in 1902, his British patent No. 24781, describing a systematic method of multiple reheating which was intended to approach as closely as practicable with a steam turbine to the isothermal expansion process described by Carnot. It was Ferranti's idea also to introduce a regenerator in order to drop the steam temperature efficiently from the last reheat to the lower temperature level. His regenerator in the patent takes the form of a feed water heater. The patent is remarkable for the thoroughness of the description and the considerable number of drawings which accompanied it ; there are seventeen sheets of drawings and one of these shows quite clearly the picture of a Lancashire boiler with a series of resuperheater elements at the exhaust end of the main flue ; the steam turbine sits on top of these in such a manner as to give a very short connection between the turbine cylinder and the resuperheater surfaces, which are of hairpin shape. In another of the drawings the reheater turbine is shown with no less than seven stages of reheat. Ferranti also shows separate valve gear for the admission of the steam to each of these stages of reheat, this valve gear being operated by a common spindle which is connected to the turbine governor.

Later on, in 1906, Ferranti took out his British patent No. 14692 for step-by-step feed heating, and there is no record of anyone having attempted feed heating in this particular fashion before that date. The object was to make the process much more nearly reversible than was possible with a single stage of bleeding, and Ferranti was the first to realise that it was very much easier to do this with a Parsons turbine because of the comparatively large number of small stages of temperature drop. About two years later a similar patent was obtained in the United States.

Later on Ferranti took out other patents on this subject, and in 1910 he constructed a 3000kW steam turbine and installed it in the River Don Works of Vickers, Sons and Maxim, in Sheffield. At the 1924 World Power Conference, in the discussion on "Steam Utilisation," on Friday, July 4, 1924, Parsons and Ferranti were both present and Ferranti described the thoughts which had prompted him to build the River Don Works turbine incorporating his invention of reheating and feed heating. He admitted that by this time he had had to reduce the several stages of reheating. He said : "The idea of the isothermal expansion at that time had got watered down to doing it in two stages. It had had a regenerator in the circuit between the exhaust and the condenser, and later on it had been fitted with an arrangement for bleeding at four stages." He described some of the teething troubles and confirmed that the performance had been satisfactory. He also described his experiments with a gas turbine wheel running at 900 deg. Cent., this being supplied with gas from a separate gas generator. Parsons followed on immediately and said he fully endorsed everything Dr. Ferranti had said. He had helped Ferranti in the construction of the turbine cylinders and the blading. No doubt, at that time, Ferranti could have lost everything by ignorance of blading design which he might have gained through a superior thermodynamic cycle, but Parsons was quite clearly big enough in mind to help Ferranti out to the best of his ability, even although Parsons himself may have been dubious at that time about whether reheating and feed heating were worth while. It will be remembered in this connection that according to the history of the subject, referred to in your original article and by Sir Claude Gibb, Parsons' own effort at reheating with one of the Elberfeld machines had shown no gain ; and in fact in a later part of that article it is mentioned that the brass blading of one of the Elberfeld machines was wrecked by the application of excessive temperature in a separately fired reheater. Ferranti's River Don Works reheaters were also separately fired.

Dr. Charles Merz, on an earlier occasion in the same conference, mentioned that Ferranti's ideas had had a very considerable influence on the decision towards the end of the first world war and immediately afterwards, to go for higher pressures and temperatures, reheating and feed heating, in the group of North East England stations which were the pioneers in doing this. The circumstantial evidence and the fact that Ferranti did at last get some reward from the reheating installations in the Commonwealth Edison Company's station in Chicago, where Parsons' largest machine at that time was installed, indicates quite clearly where the credit for these improvements should mainly go.

Ferranti's stage-by-stage feed heating has been a success right from the start and is universal. This is not so of reheating, and opinions are still divided because, in some minds, the gain is small relative to the engineering complications, and there are probably other ways easier from an engineering and operating point of view, of getting the same result.

I might end this letter with an observation which was made by the American engineer, W. S. Monroe, at the same conference. In opening his paper on "High Pressure Steam," he said dispassionately that : "It was due to the activities of Sir Charles A. Parsons that the turbine became a commercial development, and his name stands in about the same relation to the steam turbine as does that of Watt to the steam engine."

J. F. FIELD

Edinburgh, July 15th.

STANDARDISATION OF X-RAY APPARATUS

SIR,—I have read with great interest Mr. V. E. Pullin's article on "Standardisation of X-Ray Apparatus" (THE ENGINEER, June 18, 1954).

If I understand it correctly, Mr. Pullin's argument is that there are three classes of radiography and therefore only three types of unit are necessary.

A 400kV unit is proposed for boilermakers and heavy steel engineering. Frequently, however, a boilermaker may never make vessels of plate more than 1½in thick, in which case the purchase of a 400kV unit would be wasteful outlay of capital ; 250kV is suggested as a suitable power for a set for light alloy inspection. Again, most light alloy foundries, however, find that 150kV is sufficient for their needs. On the other hand, a 100kV set, although suitable for shipyards, would not be sufficiently powerful for the majority of site work where steel thicknesses of over 1in are common. Quite often a 175kV set is called for.

Mr. Pullin's classification of radiographic work, while perfectly valid as a rough grouping, fails to allow for the variety of work within each classification. The speed of work, the quality of the radiographs and the mobility of equipment required vary from case to case and the choice of suitable isotopes or X-ray equipment depends on a combination of these and other factors, such as availability of capital and working space.

If by standardisation Mr. Pullin means that only limited types and sizes of X-ray units should be manufactured, the user's choice would be very restricted and the manufacturer would be unable to produce improved units or sets designed for special applications.

There are a number of minor points in Mr. Pullin's article on which I should like to comment. Mr. Pullin says that in radiography of Class I welding every possible refinement of radiographic technique should be used. It is interesting to note that the Germans now almost invariably use lead intensifying screens instead of salt screens. A further improvement might be the more general use of constant potential circuits in X-ray equipment because of the increased penetration available and the elimination of cable breakdowns. Mention is also made of a cobalt-60 container for sources up to 5 curies with remote control. Another mobile container is available for storing cobalt sources up to 10 curies. The source is blown into position for radiography, a method which has been used in hospitals for many years with great success.

E. W. KOWOL

London, W.9,
July 12th.

Books Received

Chemical Engineering Materials. By F. Rumford. London : Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 32s. 6d.

Repair of the Small Electric Motor. By Karl Wilkinson. London : E. and F. N. Spon, Ltd., 22, Henrietta Street, W.C.2. Price 20s.

Qualifications for Special Library Work

By A. G. KAY

The author is Patents and Intelligence Officer in a large industrial concern. He is very critical of the Library Association's examinations in so far as they are applied to workers in and about special libraries, however suitable they are for librarians of public libraries. After attempting definitions of the terms "librarian," "information officer" and "intelligence officer" he goes on to discuss their differing functions and the kinds of training suited to their needs.

THE growth of the so-called "special" library catering for something almost completely removed from the ambit of the municipal library has given rise to a number of problems which have been matters of contention between the "special" librarians and their much longer-established colleagues. Pride of place, however, must be given to the long-drawn, and not altogether friendly, arguments on the qualifications—both relative and absolute—required for the respective custodians of the libraries.

Public Libraries

For many years now, municipal librarians have had their own association to look after their interests, set up some standard of training and award recognition in the way of diplomas for being successful in the examinations held by that body. The reasons for the success of the Library Association are not really difficult to discover: the Association is, in effect, a trade union in the same way as the B.M.A., The Law Society, or the Auctioneers' Institute are trade unions on a professional level, and so it has the function not merely of ensuring that its members receive adequate remuneration, but also of regulating the intake of its members and demanding certain qualifications for the privilege of its tutelage. To say this is not by any means to suggest the polite sniff of deprecation; rather the contrary—it has worked well for others, why not for librarians? The reason that it can work so well lies, I suggest, in the very fact that up and down the country there are thousands of municipal libraries; they differ, it is true, in the size and character of the population they cater for, the number of books they stock, the particular brand of furniture they use, and so on, but—basically—they handle the same kind of material and do the same thing with it, so that you can lift Mr. X from A and put him in the corresponding position in B or C and he will almost immediately be at home. The usual public library is fundamentally almost exclusively concerned with the handling and lending-out of books. Almost universally Dewey is used to classify this material. There is a certain uniformity about public libraries, so that whether one is in Liverpool or London, Selkirk or Stockport, it is possible to walk in and be able to find a particular book immediately. This is most certainly not something to be condemned; it offers many advantages and there is every reason why things should continue in this way, and I record this simply to make my point. I am aware, of course, that it will be immediately pointed out to me that there are a hundred and one ways in which the duties of the librarians differ, and I agree that they do differ—but only in minor details in the actual function and running of the library as distinct from the contacts and negotiations with local government officials.

It is because there is this uniformity that the Library Association works so well; it is because the same kind of training is required in almost every public library in the country that the L.A. qualifications are widely recognised and, conversely, it is because the same sort of function is expected of virtually every public librarian that the L.A. can draw up a syllabus which covers all the ground that a public librarian can expect to require.

University Librarians

All this is probably pretty stale and I imagine has been said before, but there is one significant point still to be made, and that is in connection with university librarians. Now the university librarian has lived in amity with his "public" colleagues for a long time and I don't want to sow discord between them, but a glance at the qualifications of the university librarians in this country will show that, whereas an L.A. qualification is recognised as fitting a man to be in control of a public library, it is not always sufficient for a man who wishes to be in charge of a university library. How many of them have a simple A.L.A. or F.L.A. qualification? How many of them have M.A., B.A., B.Litt., or other degree as well, and how does this number compare with the degrees of public librarians in proportion? How many universities, in other words, ask for a university education in addition to library training and how many are prepared to accept a man with a university degree but no library qualification, but not the other way round? I suggest that the L.A. diploma is of secondary importance in the university library and that this is so is due to the fact that there is the element of the "special" library about the university; the librarian there, because he is not concerned with the routine that is found up and down the country in public libraries, is required to have something the normal library qualification cannot and does not set out to give him. Because university librarians were so few in number compared with the municipal librarians, little attention was paid to their special needs; what small attention was in fact given could usually take the form of an addition to the existing syllabus as an optional subject. To obtain a qualification from the L.A. the university librarian had to wade through a great amount of useless lumber, especially in the preliminary stages, and so small was his voice that it hardly seemed worth while doing anything about it. Attempts at similarly fobbing off the "special" librarian are in progress now.

Library Association Courses

Where does all this lead? To me it leads to the conclusion that the Library Association sets out to ensure a training and a qualification which primarily will befit a person to administer a public library and be able to handle reasonably competently the organisation and the day-to-day routine of such a library. All these words to reach a conclusion which was so obvious to start off with! Not quite. I do not think that there is a single librarian of any sort who would disagree with my summary statement and yet would not ignore it completely in any argument about the qualifications and training required for a "special" librarian. Surely the whole point is that the training, the focus, the entire slant of the L.A. courses, is directed to the field of public libraries, that by accident or design, or by reason of this very fact, the L.A. courses and the public libraries are perfect matches for each other, but that all this applies to—and applies only to—public libraries. The L.A., I know, has recently acknowledged this fact by adding special parts (like the documentation of science) to the examinations. I maintain, however, that merely sticking on bits and pieces to the syllabus in the hope of catering for a new and different field betokens a lack of knowledge of what is really required in that field. I am not taking a dig at the officers of the L.A. or the public librarians generally in saying this—it is fairly obvious that a public librarian cannot reasonably be expected to know the ins and outs of a class of library which has really become significant in only the past ten years and from which he (and the public generally) is completely excluded.

An attempt to answer this point will be made by referring to those engaged in special library work who are on various committees in the L.A. and who assist in the drawing up of those parts of the syllabus designed for the special librarian. It is obvious, however, that the total effect of this representation cannot be other than small, especially when pitted against the entrenched traditions of years, coupled with the extreme bias on the side of the public library. I know that discussions on qualifications are being held between ASLIB and the Library Association, but I shall be surprised if these are solidly based on the real differences between the public and special librarians.

The implications of what I have been saying seem to be that the person in charge of a special library is a being apart from the public librarian. This needs closer examination.

Special Libraries

I had better indicate first of all what I mean by a "special" library. Any library which caters for a special and limited branch of knowledge—professional, scientific or artistic—is a special library. Most of these libraries are attached to some body or association such as a professional institute, a commercial or industrial undertaking or scientific organisation. It becomes obvious immediately that the diversity of such libraries is enormous. Some of them will differ from a public library very little—perhaps merely in that the number of users is limited and its users will perhaps all be of one profession. Others of them will differ in practically every aspect in which it is possible for them to differ. Again, the material handled and the emphasis will often be very different both from public libraries and even from each other. Whereas (apart from the reference section) books are almost the sole basic material dealt with in the public library, the special library will frequently have to deal with a host of miscellaneous documents ranging from highly secret internal reports, pamphlets, patent specifications, correspondence and periodicals, all the way to the straightforward text book; in addition, it is not merely the document as a whole that is of interest, but frequently quite specific detailed information contained in the document, which may even be a complete side-

line to the main subject. Queries encountered will run from a single specific point—such as information on the chemical whose trade name is "X"—to a request for a complete survey and appreciation of development in some technical field.

It is this very great diversity, not only in the scope, purpose, function and type of the libraries themselves, but also in the functions and duties of the people in charge of them, that distinguishes the "special" libraries and their librarians from their longer established colleagues, and it is this also that makes it so necessary that their particular needs are recognised.

Librarians, Information Officers and Intelligence Officers

As I have indicated, the duties of different librarians are as varied as the libraries themselves. This, of course, is exceedingly thin ice amongst special librarians at the moment. The controversy about "librarians," "information officers" and "intelligence officers" in THE ENGINEER* ended months ago, but it will be long before the dust finally settles. Nothing was proved by this argument and very little clarified, except the fact that these titles are used indiscriminately to describe the duties of the various persons in charge of the various libraries.

I hesitate to trample the ground so delicately tip-toed by the angels, but I think that before any clear thinking can be done on this subject or the subject of qualifications, some sort of definition, even if only a working definition, must be sought. I know that no attempt will satisfy all, that there will always be grounds for criticism even by the most helpful and that, above all, it is impossible to arrive at absolutely clear distinctions; nevertheless, it is essential to extract some order from the confusion existing at present. Using the three terms commonly bandied about just now, then, I suggest that their various meanings be somewhat as follows :—

Librarian.—A person who is in charge of a library or collection of books, music, records, films or documents of one sort or another and whose duties consist of the day-to-day running of the library and involve such matters as cataloguing, recording and accessing the receipt of material for the library, the supervision of lending and borrowing, book selection, choice and arrangement of furniture, choice of classification and the work of classifying, photo-copying, organisation of staff to carry out this work—and other such items as fall strictly into library routine.

Information Officer.—A person who is primarily responsible for purveying facts, who is skilled in the sources of reference and who can be expected to answer queries on definite topics. Liaison, public relations and even publicity might conveniently be considered as either coterminous or complementary functions. This kind of duty is by no means unknown within industry and commerce to-day; in the public library I suggest that the reference library would be the normal habitat of the animal.

Intelligence Officer.—A person who is required to make qualitative—and perhaps even quantitative—evaluations of facts and information; who is required, also, to perform the task of advising on the trends, probabilities and developments in particular fields.

Let me immediately forestall the criticism that these distinctions are not clear-cut in fact. I know they are not. Throughout the hundreds of libraries, information centres, intelligence departments and so on in this country the complete gamut is run from people who would fit as closely into one of these categories as an arm in its socket to those who combine one or more of these functions or bits of them along with some I have not mentioned. I know, too, that there are activities such as translating which have not been mentioned. So far as the first point is concerned, it is precisely because there is this continuous spectrum that there is confusion and consequently the necessity for a definition which may, in time, assist in clearing that confusion; at the moment we are often arguing on terms which sound the same but are completely different. On the other point—I have no intention of trying to make an exhaustive catalogue of the various functions; given the main skeleton, the padding can be placed as appropriate.

Practical Experience

If the definitions I have put forward are accepted as following even only roughly the actuality of special library functions, further discussion, to my mind, becomes more fruitful. (For the rest of this article I shall use the three terms as defined to cover the particular functions I have outlined.) It becomes obvious, for instance, that whatever the actual contents of the library—books, music, or what have you—the librarian will benefit greatly by some parts of the training and education set forth in the L.A. syllabus. I think it must still be recognised that the work of the librarian is very much a practical art which can, ultimately, only be learned with any degree of thoroughness by practice at it—in other words, by experience. Apprenticeship, if you care to call it that, actually in a library, doing the day-to-day jobs, is absolutely essential and there is no substitute for it. This training can, with great benefit, be supplemented and assisted by parts of the A.L.A. course. It is of value that some guarantee, in the way of a diploma, be given, so that a candidate can satisfy a potential employer that he has the necessary basic experience and has been able to convince the examiners of the L.A. that he has some idea of what he is doing and, even more important, why he is doing it. I should like to say, however, with all the emphasis I can command, first, that notwithstanding these comments, I would never consider the mere lack of a paper qualification to bar a candidate, if that candidate could show sufficient experience and give evidence also of an alert mind that would learn quickly. Secondly, all that I have said in this paragraph applies to a library dealing with scientific and artistic or commercial material just as much to a public library. In vindication of my attitude towards paper qualifications, I would simply point out that the L.A. itself normally demands a period of training in a library, thereby recognising, if only tacitly, that initially the art of the librarian is largely practical. In dealing with the practical, rigid lines are artificial and great flexibility of attitude is required to take into account the different abilities of different personalities, as well as formal qualifications.

I would say, then, that the special librarian requires, preferably, some formal training as a supplement to his practical experience. I am of the opinion that the L.A. is in the best position to supply this training—provided that it can shake off the dead weight of public library tradition and realise that special libraries have come to stay and that they demand a treatment in many ways different from that of the public library course. I think that the L.A. is in the best position to supply this training—given the qualification I have just made—because it has already the status and organisation and in a small specialised profession such as librarianship there is really not room for two organisations doing essentially the same job. I am not absolutely convinced upon this point, however, especially as I admit to being just a little scared lest that body is unable to wake itself up sufficiently to give the curriculum the radical shake up it must have if it is to be of value for special libraries. The actual syllabus itself I shall deal with later. Before leaving the subject, however, I should like to make it clear that I am suggesting two courses of study—one as at the moment for public library students and a course specially designed for special library workers, entrance for either being through a common entrance examination.

Undoubtedly difficulties arise in considering the training required by intelligence officers and information officers. One difficulty can be disposed fairly quickly—I think we must disentangle our minds of the confusion we bring upon ourselves by harping on the multiple duties which information or intelligence officers may be required to perform. If one person acts in the capacity of all three, then obviously that person must, ideally, have the training for all three; if an intelligence officer acts as his own librarian then he will obviously benefit from having had some training as a librarian. Let us also be careful about confusing ourselves with the intelligence officer who is responsible for a library, but has on his staff someone who actually does the work of a librarian. In this case, to my mind, the intelligence officer need have no formal library training but, one would imagine, have sufficient "savvy" to have learned sufficient of library method to be able to take an intelligent interest in what is going on and to be able to advise, at least, on matters of policy.

It is, I think, worth mentioning that although the combination of duties is often met, particularly in small organisations, it becomes exceedingly difficult to fulfil all capacities really adequately beyond quite a small limit. A superman may be able to devote the care and attention to all the daily routine of running a library and at the same time have opportunity and thought for the research work and interpretation of it required for intelligence work. Few of us can claim that distinction. It will usually be found that those who claim to be engaged on this combination are, in fact, concentrating on one side or the other, the remaining side limping along as best it can or having the attention of an "assistant."

The information officer, on my definition, is an in-between character who is neither fish nor fowl, but that is largely because I am of the opinion that he does not rightly, on that basis, claim to be considered as properly part of the special library staff. He is more of an adjunct than anything else and in the library proper his duties would usually be taken over by the librarian or a senior, fairly experienced, assistant. This officer would be more likely to be found in one of the other departments suggested—public relations or publicity. I believe that for a person having the functions outlined a stay in the library of from three to six months would be adequate. In that time it should be possible to become familiar with the general run of the library, the intake and the sort of material which one may expect to find there. I know that the L.A. devotes some time to training on the various reference books available and their use. I should say that this would be valuable supplementary training, but again I feel that a person might

* "Library Service for Industry," by K. J. Rider, February 13, 1953, and correspondence in following issues.

well be able to make himself thoroughly familiar with works of reference, especially in a limited field, by himself—perhaps I am over-estimating the general run of capabilities. At any rate, an intensive course on the subject of reference books would not be amiss; as well as this a course on dealing with people (especially for work where he comes into contact with the general public)—manners and approach, a training on the writing of good English and lessons on clear self-expression, would provide an excellent background for what is essentially a practical and personal art where memory and personality are at a premium.

Intelligence Officers

Because it is usually considered that an intelligence officer is a cut above the librarian, the former title is sometimes used to cover a job which is little more than that of looking after a few books and reports—as a fillip to the holder of that job—and it may even be self-bestowed. As judged from quite a few intelligence officers in industry, however, it is usually true that that position does carry a senior status, a comparatively high salary, considerable responsibility and, not infrequently, authority over the library and librarian. Again, it is not possible to lay down hard and fast rules about the duties involved in this position, as they differ fairly widely from place to place, but it is possible to arrive at fairly reasonable common denominators. First and foremost the intelligence officer must be completely familiar with the aims of his organisation, with all the products manufactured (if it is an industrial concern), with all the methods of production and manufacture, with all research and development work taking place, with all ancillary activities such as staff welfare, training courses, medical supervision, and so on, with the possible hazards of the processes of manufacture, as well as the basic sciences and technologies used in the research, manufacture and maintenance connected with the products. This may seem like a tall order, but I believe that this job cannot be done properly by anyone less well informed than I have suggested. With this background knowledge he should be able to make a wise choice in the buying of journals, technical literature of all sorts and other material; he should also be able to judge what information, technical articles, commercial news, &c., will be of interest (and to whom); further, he should be able, either by doing the job himself or through abstractors or both, first to ensure that all this information reaches the people to whom it is of most concern, secondly, to decide how much of it is worth keeping permanently and, thirdly, deciding (and if necessary devising) the best method of keeping the permanent information on tap for quick reference. As well as this, he should be able to survey a given field and make an assessment on a variety of points connected with it—such as state of technical development, possibilities of further development or, according to his qualifications, commercial trends or market possibilities. On this basis, and doing his job properly, the intelligence officer earns his senior status and all that goes with it; it is a job, however, which not only can be done but is being done every day in quite a number of places.

Training of Intelligence Officers

It immediately becomes apparent on this recital of duties that the training set out, or even envisaged by either ASLIB or the L.A. (as shown by their past statements on the subject) has no relevance whatsoever. The A.L.A. diploma is about as much use for this sort of job as a degree in dish-washing would be to a surgeon. My candid opinion on this matter, for what it is worth, is that there is no scheme of training which either body has devised, or is ever likely to devise if left to itself, that is likely to be more than of mere passing interest. The actual daily duties of the intelligence officer, as indicated here, defy classification because they will vary fundamentally and widely from one place to another even although it is possible, as I have just done, to describe them broadly. It is virtually indispensable that the intelligence officer should be able to call upon the services of a library, and actually preferable that he should be in charge of it, but it is no more necessary for him to follow the daily workings of it than it is necessary to know the mechanism of an alarm clock before using it.

It follows also that the type of organisation should determine the basic qualifications required. If, for example, it is the research department of an electrical engineering concern, then the primary attribute should be a knowledge of electrical engineering; on the other hand, if the position is one in a concern marketing popular consumer goods, then it is not unlikely that a knowledge of statistics and economics would be the most helpful. It will, I hope, be observed that I make no dogmatic assertions about this, because I emphasise that this is not a subject where dogmatism is compatible with the observed facts. Success in this kind of work is, I think, at least as dependent upon the person—his attitude towards it, his personality, his receptivity, intelligence and quickness of mind, as upon paper qualifications. This may offend some, but I think that this matter is largely one of personal opinion, and that is mine. I do *not* suggest that paper qualifications are unnecessary or of no value; for very highly specialised work they may, indeed, be essential. For the most part, however, I suggest that the position is that already outlined for the librarian—given the correct person, experience will go far towards success; given an unsuitable person, no amount of academic qualification is likely to achieve much. So that, again, a degree or specialist training in the particular interest of the employing concern is highly desirable—much more so than in the case of the librarian—but the lack of this should not necessarily be an absolute bar; this must be coupled with experience and the necessary personal attributes outlined. There are many jobs where the person, as contrasted with the paper qualifications, is the paramount factor and in my opinion the attempt to make a strait-jacket of courses, diplomas, degrees and what-have-you for this sort of job is simply chasing rainbows.

Courses for Intelligence Officers

Is the aspiring intelligence officer to be left, then, to sweat it out for himself? Not quite. I would suggest a number of courses which would be helpful. I have already noted, however, the point that in practice it is often very difficult to separate the different functions and, in small organisations, it is obvious that one person is quite frequently going to have to do some doubling-up on the various parts. To be realistic, any course intended to be of use to people engaged on special library work will have to add much that does not now appear in the L.A. syllabus and a lot will have to be dropped. I would suggest that study on the subject of legislation relating to public libraries be omitted, as also on library committees, finance, accounts and annual reports, along with history of libraries and things like English literature. Courses on systems of accession, cataloguing, classification, lending and other pure library work are still necessary but not on the exhaustive lines of the present courses; emphasis on the philosophy and wider aspects of these subjects—the "why" rather than the "how"—seems more appropriate. In addition, I would add a course on English—the real down-to-earth of letter-writing, self-expression and clear and precise presentation of information. (Elementary? Perhaps so, but judging by some of the material one sees, very necessary in this as in other walks of life.) Other material I should include—information on book and periodical publishing; logic—not the dry-as-dust and hopelessly impractical text book stuff but the presentation of arguments, clear thinking, the assessments of facts and the drawing of inferences; a course on Patent Law—this would be of immense value especially for one engaged in the technical field; abstracting and précis work—how to pick out the pith and marrow of documents; a course on the production of bulletins, reports, reviews, and so on (ASLIB ran a course on this a while ago which, from what I could gather, was fairly practical and of value); a course on copying, printing, duplicating and reproduction of documents in general. I do not suggest that this is an exhaustive list, but it does indicate the lines along which I think any training scheme for intelligence officers should be run.

I am of the opinion also that it should be possible for students in all the large cities and towns of this country to study for the L.A. diploma—either course—at evening classes. Study for higher or special qualifications should not be the preserve of those who can devote some time during the day. Neither, on the other hand, should the evening student be at a disadvantage (any more than is inherent in evening study, anyway) in comparison with his day colleague.

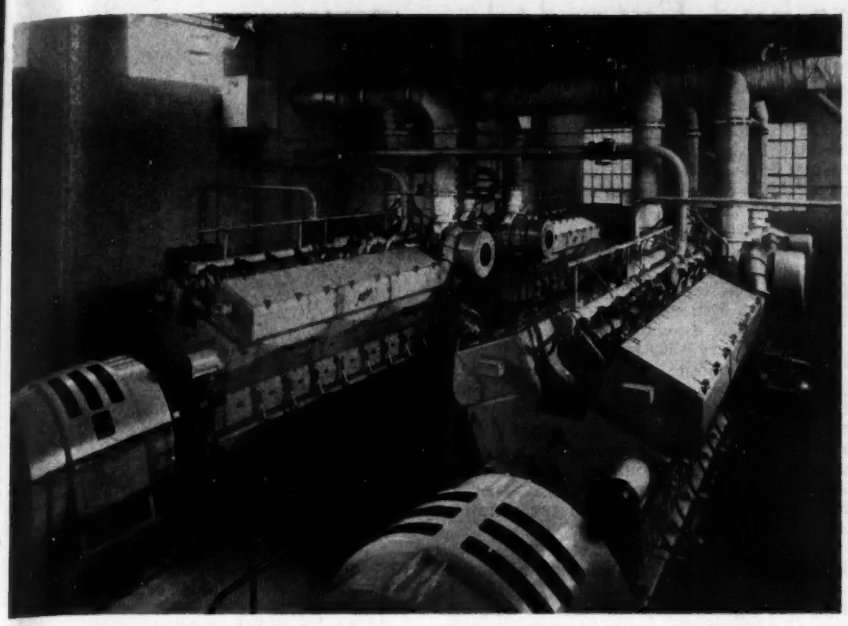
One final point—in this article I claim neither to have offered the complete solution to all problems in this field, nor to have dealt with the subject exhaustively. If by my comments and suggestions I shall have stimulated discussion and in any way helped towards a clear appreciation of the special libraries' needs, then I shall be quite satisfied.

Private Diesel Generating Station

We were invited recently by the Bristol Aeroplane Company, Ltd., to visit its diesel generating installation which, having a capacity of 10,250kW, is thought to be the largest private oil-engined factory generating plant installed in this country since the war. It comprises three separate stations connected to the factory's 11kV distribution system.

The scheme for the provision of the first of these three stations took shape as a result of the power crisis of 1946–47. Plans were then urgently put in hand for the installation of three American 1200kW generating sets at the Gypsy Patch site in the Engine Division. These sets were originally spares for naval frigates and were installed within five months.

Within a few years the increasing pressure of defence programme commitments and, in particular, the expansion of the company's turbine research programme, made it necessary to do more than double the capacity of the supply from the Electricity Board, and for the same reason development of the company's standby power supply was desirable. This development took the form of six 1000kW diesel alternator plants, four to be installed at the Engine Division's East Works in order to back up the Gypsy Patch station, and two to be sited at Filton to serve the Aircraft Division. Dispersal in this way was necessary for a number of reasons—from the point of view of works defence requirements, use of existing buildings and the technical



The four Mirrlees Brush alternator sets at the East Works, Filton, power station

desirability of siting the sources of power in the areas of greatest need.

All generation is carried out in parallel with the public supply in accordance with general practice. Each generating set is equipped with the necessary protection to meet the supply authority's requirements. It is pointed out that the whole arrangement is working in the closest co-operation with the South Western Electricity Board, which welcomes this additional generating capacity available for use at times of peak load as well as to meet standby requirements.

The three General Motors units are two stroke uniflow scavenge, sixteen cylinder, vee, diesel engines, of 1700 h.p. each, and they have performed reasonably satisfactorily during the past seven years. The bore and stroke is 8·75in by 10·5in, respectively, with a direct-driven Roots pattern scavenge blower operating at approximately 2½–3 lb per square inch gauge. The compressor is a two stage Reavell unit driven by a 30 h.p. slipring a.c. motor and a standby petrol-driven unit is installed which will top up the storage bottles for one or two starts.

Engine cooling is by means of closed circuit heat exchangers with Heenan and Froude mechanical forced draught coolers handling the secondary water.

The generators, also of U.S. origin, are of Allis-Chalmers manufacture and operate at 500/550V at 700/750 r.p.m., the field being separately excited by direct-driven exciters. These machines are very highly rated and are small in size for the output of 1200kW. The temperature rise is 70 deg. Cent. above ambient. Glass fibre insulation is used to cater for these high temperature conditions and the heat is dissipated by passing the cooling air in a close system through a water-cooled radiator mounted on top of the generator field yoke. The machines are connected to the engines by a short length of shafting and a flexible coupling.

In the case of sets 1 and 2 the output from each machine is taken to a change-over switching cabinet in the adjacent substation, and is fed direct to the direct current side of a rotary converter. The current is then inverted and transformed up to 11,000V and switched on to the h.t. distribution network through "C" type Reyrolle O.C.B. switchgear.

The output of No. 2 set is brought direct to the d.c. busbars in the substation and can be either used entirely locally or allowed to swing on to a rotary converter, thereby partially exporting its current at 11,000V a.c.

It is not possible to switch No. 2 set to the local d.c. load, but No. 1 set, by means of a solid link, can be connected to a special consumer unit at 500V d.c. independent of the main board. Under these conditions this set supplies stable d.c. volts for special test purposes and is used considerably in this manner. The maximum load required of the set in this form, however, is only 500kW.

East Works.—Situated in the East Works are four diesel-electric alternator sets of 1064kW capacity each. They were commissioned in 1953.

The prime movers are of Mirrlees, Bickerton and Day manufacture and comprise the company's "JVS.16" diesel engine. This engine is a sixteen cylinder, vee, four stroke exhaust gas, turbo-charged unit developing 1520 b.h.p. at 750 r.p.m., with a twelve-hour rating in accordance with B.S.S. 649 : 1949. The bore and stroke are 9·75in by 10·5in, respectively. The turbo-chargers operate on the Buchi principle and are manufactured by Brown-Boveri of Switzerland. Rated b.m.e.p. is 128 lb per square inch, compression ratio 12·15 : 1, maximum pressure approximately 1100 lb per square inch, and the piston speed at 750 r.p.m. is 1312ft per minute.

Engine cooling is by the closed circuit heat exchanger system with the secondary circuit or raw water side handled by Heenan and Froude evaporative mechanical coolers. All engine auxiliaries, with the exception of the lubricating oil priming pumps, are housed in an annexe constructed on the north side of the main power station hall and this annexe also accommodates a workshop and a general store handling spares and equipment for all generating plant in the factory.

Also situated in this store-room is an injector nozzle reconditioning unit and a testing rig for fuel injectors. With this equipment, reconditioning and maintenance of all the various kinds of fuel injector nozzles used in the factory, including various mobile units for aircraft engine starting duties, &c., can be handled.

The engines are coupled to salient pole, single pedestal bearing alternators with overhung exciters of the Brush Electrical Company's manufacture. These machines generate at 3·3kV and their output is transformed up to 11kV through solidly coupled auto-transformers made by the same firm, and switched on to the 11kV network through remotely operated Reyrolle "C" type switchgear.

The four sets are sited in the main hall, as shown, back to back in two pairs, so that the control stations are brought together in a centrally placed walkway. An alarm system offers protection for engine services covering low lubricating oil pressure, failure of water circulation and high water outlet temperature, and these are monitored and registered through pressure and thermostats, by audible and visual means on a control panel adjacent to the main entrance door. Remote operation push-button stations for all pumping services are also situated on this panel, together with the telegraph system of communication with the load control centre.

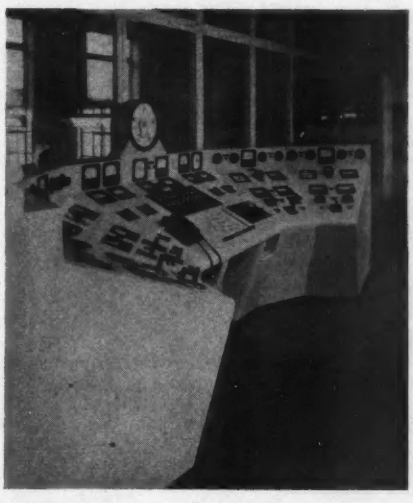
Control of each set in this station is effected at the load control centre, which is sited in a room arranged at one end of this station approximately 12ft above the floor level. A switch panel contains the necessary instruments and switches for paralleling, synchronising and remotely closing the O.C.B. Control of the engine load speed mechanism, voltage and power factor rheostat is also effected from the desk and these respective mechanisms are actuated by geared motors suitably protected by limit switches. The exciter field rheostat, field suppression switch and earthing changeover links are housed in small cabinets, one cabinet containing the equipment for two engines.

Filton Station.—The Filton station is basically similar to the East Works layout, but contains only two Mirrlees/Brush "JVS" 16/1064kW alternator sets. They are controlled locally at a small desk containing similar sets of instruments for each engine. An alarm system, together with the necessary push-button stations, is similar in principle to the larger one at East Works.

House supplies and power for emergency operation of the solenoid-operated Reyrolle O.C.B. is derived from a radiator-cooled Paxman-engined 45kW, self-contained alternator set, and this machine has sufficient capacity to carry the complete services of the power station and adjacent special services in the event of emergency.

Load Control Centre, East Works.—As previously indicated, this centre is the headquarters of the load control and at a main load control desk, shown below, is concentrated all the information covering the loading of the works electrical distribution system. This information indicates to the operator the demands made by various sections of the works, in particular the Turbine Test Department, and enables action to be taken to control the supply so as to maintain a balanced system and a controlled maximum demand. Power factor correction condensers, recently installed at the various substations to maintain economical use of power, are controlled from this desk, as are also the nine diesel alternator sets. The communication system radiating from this centre comprises a network of private telephone lines connecting all of the company's h.t. substations and selected key personnel.

Centrally situated on the desk is a push-button electric telegraph system in communication with the three main generating stations and affording the operational means of starting and stopping generation as required. This is achieved by light signals illuminating a lettered glass panel at each of the power stations, indicating the number of sets to be started and stopped as required. Light signals at the control panel indicate the sets on load. A large 18in dial meter tells the operator at a glance the total maximum demand on the system and the telegraph panel shows the amount of generation running at any given moment.



The control desk, showing telegraph system and control instruments, at the main load control centre at East Works

Taper Disc Rolling and Extruded Ring Forming

AS the gas turbine is essentially cylindrical, considerable numbers of flanges and rings are used in its construction. They may vary greatly both in their profile and, according to their location, in the material used. In most cases machining to precision limits is essential, and there promises to be important economic and metallurgical advantages from the use of extruded alloy steel sections which recent advances in this technique have made available. An additional production problem is presented by the numerous stages in an axial compressor, for not only has each stage a flange on which to locate the blades but its disc, which is of very narrow section, has also to be tapered.

Earlier references to these aspects of gas turbine component manufacture have appeared in these columns, dealing notably with extruded ring fabrication and taper disc machining. Recently we visited the Dunlop Rim and Wheel Company, Ltd., which is one of several companies where different manipulating and forming techniques to save material and machining time on gas turbine components are being evaluated. At this works both ring forming and a hot rolled taper disc forming techniques are being developed.

Hot Rolled Taper Discs

The machine described previously in these columns* received a previously rough machined disc, the two faces of which were simultaneously profiled so that the cutting load was balanced and distortion of the thin disc section avoided. Alternatively a rough forging was used.

At the Dunlop works the process used in the manufacture of tapered discs incorporated in heavy road wheels is being developed for the production of tapered rotor disc blanks. The heavy road wheel consists of a disc which is tapered according to diameter and loading to reduce weight as far as possible. The disc is then cold pressed before being riveted or arc welded to the rim. To machine such discs to the required taper was slow and expensive in labour cost, also wasteful in material, particularly as no other machining is required on vehicle wheels except at the hub.

A number of compressor discs, without a flange, using the same plant, have already been produced and the process, which is basically the same, is as follows.

A blank is received initially as a disc of uniform gauge across the diameter and equal to that required in the nave. A locating hole is punched in the centre of the blank before insertion in an oil-fired furnace to raise its temperature to rolling heat of 1050-1150 deg. Fah. Upon removal it is placed between the two grippers of the rolling machine, as illustrated below. A spigot of one of the grippers, which are of smaller diameter than the nave, locates through the centre hole of the blank and ensures correct alignment, before gripping, which is effected by application of hydraulic pressure.

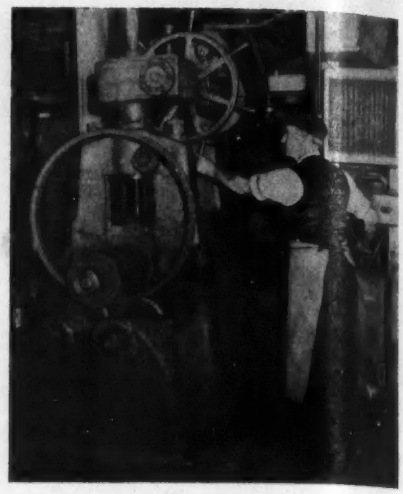
The complete assembly moves forward until the disc periphery is between two forming rollers rotating in opposite directions, positioned so that the plane of their axes intersects the common axis of the grippers and at right angles to the plane of rotation of the disc. The forming rollers are truncated cones with the inclined surface of each roll set obliquely outwards to form a vee with its open end towards the disc. They are then closed in uniformly to a predetermined setting for the required thickness.

As the disc comes into contact with the rollers it rotates by friction and is fed forward into the wedge space between them until the desired degree of taper is achieved. Jets of water are directed on to the disc to eliminate distortion or thinning at the centre and to lessen formation of scale. The wheel discs are then allowed to cool in the atmosphere, tested for taper thickness and trimmed to the required finished diameter in readiness for ensuing press work prior to the fitting to the rim. In the case of the compressor discs more extensive heat treatment is required before final machining to close limits. If required the disc can be dished before machining by pressing.

The task of forming a tapered disc with an integral rim or flange from a flat blank using the same basic plant presents a number of additional problems. In this case an attempt is made to restrain diametral growth of the disc whilst inducing the displaced metal to form the flange. Experimental rolls are being used in an endeavour to achieve this attractive solution to the forming of a flanged disc.

Extruded Ring Manufacture

The extrusion and the ring forming of complex sections in stainless steels for use in gas turbines was a subject of an earlier article in The Engineer. The Dunlop Company is also applying its experience and plant and installations in the manufacture of heavy wheel rims towards the development of this process. For many years quantity production of such rims has been carried out by subjecting a hot rolled steel strip to a cold circling operation followed by butt welding and final expanding or contracting sizing operations.



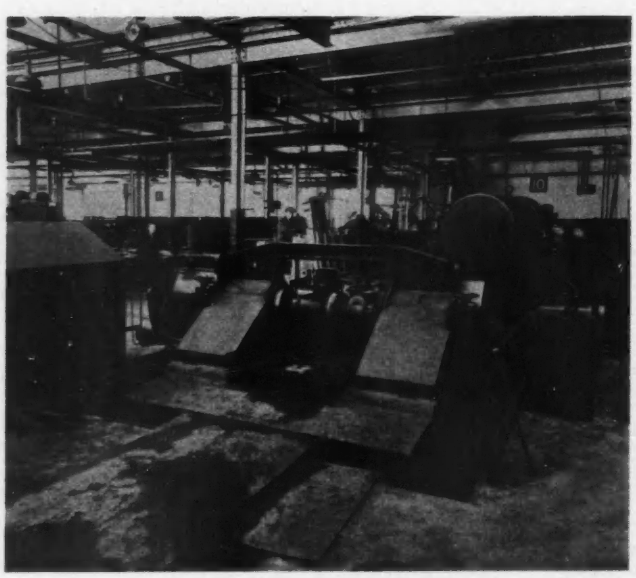
Final recircling of an extruded ring

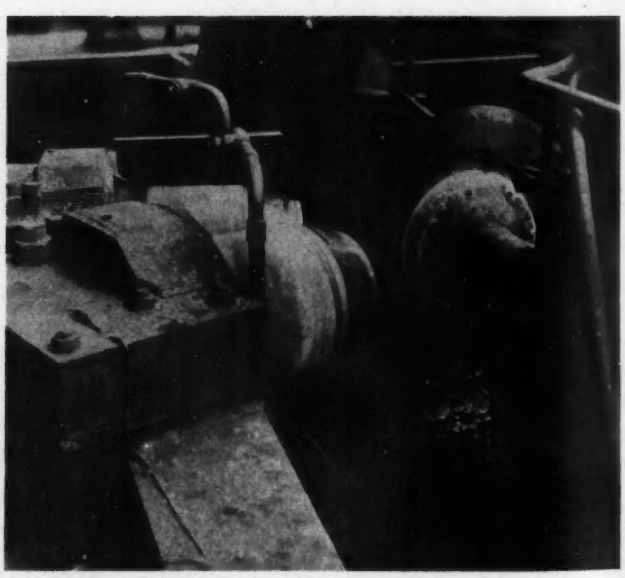
At this works raw material is received on the shop floor as an individual extruded steel strip sufficient to produce a single ring, its length being greater than the developed length of the ring to allow starting the end in the circling machine. The blank is first circled in a three-roll machine, a special set of rolls being required for each section. The overlapping straight ends of the circled strip are then removed, the ring is put through the rolls for a final recircling to bring the extremities together and a press operation follows, to impart a final rounding of the ends.

Welding is carried out on a 300kVA automatic flash butt welding machine, a special set of welding blocks being required for each of the various cross-sections. Surplus weld is removed and the joint pressed to correct any local out-of-roundness imparted to the ring by the upsetting pressure applied during the welding process. Correction of ring diameter is carried out by expansion on a segmented mandrel. In this operation the material is taken beyond the elastic limit, which serves also as a very severe test of the efficiency of the joint weld.

Stress relieving is carried out by heating to 1050 deg. Cent. and allowing it to cool in the atmosphere. If heat treatment induces ovality in the ring beyond the final machine limits the ring is re-expanded or contracted to bring it to size.

* See The Engineer, April 2, 1954.





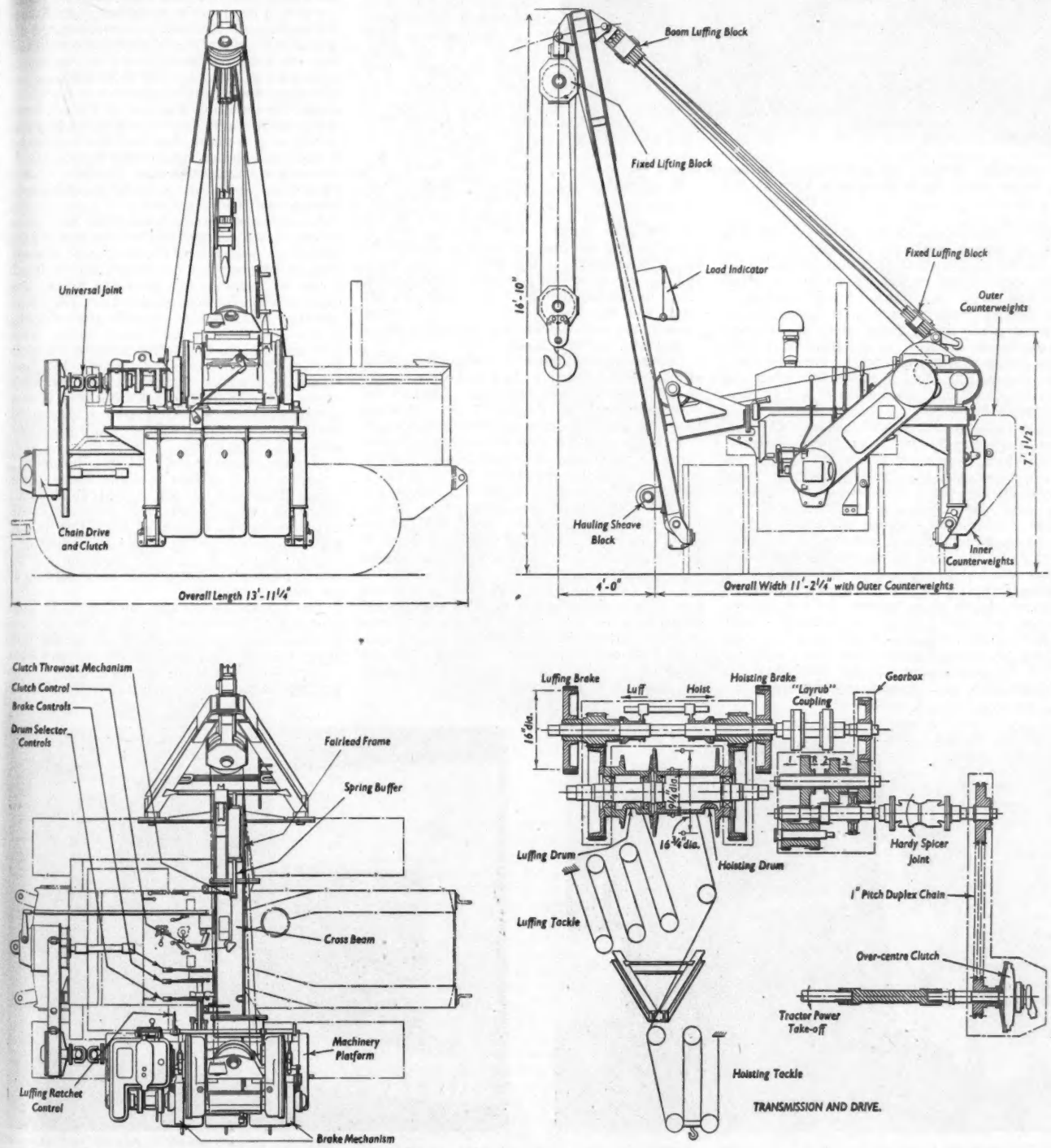
The hot disc taper rolling machines and (right) a closer view of the inclined taper rollers about to receive a disc

Side Boom Tractor Crane

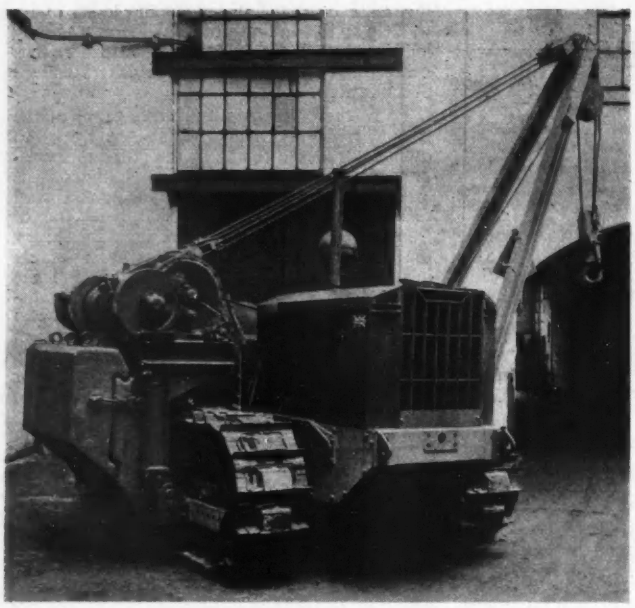
A new side boom crane now being made by Marshall Sons and Co., Ltd., for attachment to Fowler "Challenger 3" crawler tractors is particularly intended for use by oil field and pipeline contractors. It is driven from the tractor rear power take-off and is designed to handle loads from 12 tons, at 4ft outreach, to 3½ tons, at 14ft outreach.

FIELD trials have now been completed on a prototype side boom crane which has been developed by Marshall Sons and Co., Ltd., of Gainsborough for attachment to the Fowler "Challenger 3 and 4" diesel crawler tractors. This crane is one of a range of ancillary equipment to be introduced for use with "Challenger" tractors, and is particularly suited to the field requirements of oil companies and pipeline contractors. It can be fitted to a tractor without need for major modification, and is driven through a chain and gear transmission from the rear power take-off. The arrangement of the prototype crane as fitted to a "Challenger 3" tractor is shown in the photograph and drawings we reproduce herewith. The crane has a 15ft long boom, the overhang of which can be adjusted from 4ft to 14ft. At the minimum overhang it can handle loads of up to 26,900 lb, and at the maximum overhang loads of just under 8000 lb—these load ratings being in accordance with British Standard Specifications.

To fit the crane the front cross beam of the tractor, which normally permits the tracks to oscillate, is locked rigidly by the fitting of special brackets. The crane frame structure consists essentially of two assemblies of welded steel sections, one bolted on each side to the tractor frame side members, which are strengthened for the increased lateral loads. One assembly incorporates the lifting rope fairlead, and the other carries the platform for the crane transmission and the counterweights. The two assemblies are coupled together by a heavy steel box member which is bolted permanently to the main engine bulkhead and braces the tractor hull. This member is not removed when the



General arrangement of 12-ton capacity side boom crane on "Challenger 3" tractor



Machinery platform and counterweights on the off-side of side boom tractor crane, for handling loads from 12 tons at 4ft outreach to 3·5 tons at 14ft outreach

crane is dismantled, as it in no way interferes with the normal working of the tractor.

The boom is built up of reinforced 6in by 5in steel sections and its feet are pivoted in heavy brackets on the track frame. A safe load indicator is fitted on the boom, and the fairlead frame incorporates a spring buffer which is contacted if the boom is raised to a dangerous height. This buffer prevents damage to the boom and mechanism, and when it comes into effect the driving clutch is automatically and instantaneously disengaged.

The tractor power take-off runs at 1550 r.p.m. and is coupled to the crane drive through a "Rockford" over-centre clutch and a 1in pitch duplex chain. The arrangement of the main driving gear is shown in the drawing on page 135. Power is transmitted to the main driving shaft through a gearbox, giving three speeds for hoisting and one for lowering. Pinions on this shaft are in constant mesh with gears attached to the ends of the hoisting and luffing drums. The drive required is selected through sliding dogs between the two pinions on the main shaft. The pinion assembly of each motion incorporates a brake drum, and the brakes are spring loaded to the "on" position. With the arrangement adopted the brakes are automatically and immediately applied when the clutch is disengaged. When the drive selector is in the neutral position and the brakes are disengaged the hoisting and luffing drums are free spooling. A safety ratchet is provided on the luffing drum for engagement during hoisting and lowering of loads.

The 8½in diameter lifting drum has a length of 12in and takes 340ft of ¾in diameter rope or 540ft of ⅝in diameter rope. The luffing drum, of the same diameter, is 5in long and takes 120ft of ¾in rope. The drum speeds available through the gearbox are 58·8, 95·3 and 386 r.p.m. for hoisting and 53·8 r.p.m. for lowering. These drum speeds give hook speeds of 35ft, 57ft, 234ft and 32ft per minute respectively. Luffing of the boom is effected through a six-part rope system, with roller bearing sheaves at the top of the boom and mounted directly on the hoisting gear frame. The hoisting rope is carried across the front of the box member to the fairlead sheave. Controls for the crane motions are conveniently grouped to enable the driver to operate the clutch lever with his left hand, and the brakes, the hoist and luffing selector, the gear selector and the luffing drum ratchet with his right hand.

The counterweights are hooked on the outside of the hoisting assembly frame and are arranged in two banks of three segments. Each of the three inner segments weighs 1597 lb and when these are used the crane can handle maximum loads of up to 21,750 lb at 4ft overhang. When the three outer segments, which weigh 1403 lb each, are fitted the maximum weight of 26,900 lb can be lifted. Both of these load ratings are two-thirds of the corresponding tipping loads. A "Challenger 3" tractor fitted with the bare crane equipment has a total weight of 34,080 lb and with the two sets of counterweights 43,240 lb.

In the course of the tests carried out with the prototype crane the maker states that it handled 50 per cent overloads without tipping, and in a 100-hour test of continuous operation no major breakdown occurred. Batch production of the crane has now been started in the Gainsborough works of the company.

Multi-Purpose Heat-Treatment Electric Furnace

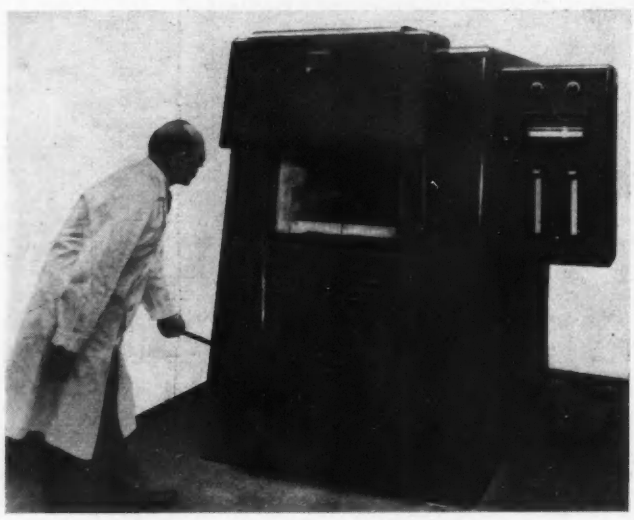
A HEAT-TREATMENT furnace designed to suit a variety of applications has been developed by Birlec, Ltd., Tyburn Road, Erdington, Birmingham. The new "RS" furnace, which is illustrated herewith, combines many of the characteristics of the company's existing "RP" and "SA" furnaces.

It may be recalled that the "RP" furnace was developed for normalising, hardening, tempering, nitriding, pack-carburising and other processes at temperatures up to 1050 deg. Cent., and was fitted with additional heating elements on the inner face of the door to compensate for heat losses at the entrance to the work chamber. The "SA" furnace, which is of similar general construction, incorporates the so-called "certain-curtain" system of atmosphere control for the clean hardening of workpieces such as tools, dies and gauges which require a scale-free finish. The system involves the admission of a mixture of town's gas or charcoal, producer gas and air through a slit in the floor of the furnace vestibule. This flow keeps the furnace chamber purged and is designed so that when the door is opened the mixture is automatically adjusted to provide a straight-up curtain of flame across the full width of the opening. Without impeding loading and unloading operations, this "curtain" serves as a protective barrier against disturbance of the atmosphere within the furnace chamber. "SA" furnaces are designed for temperatures between 700 deg. and 1050 deg. Cent.

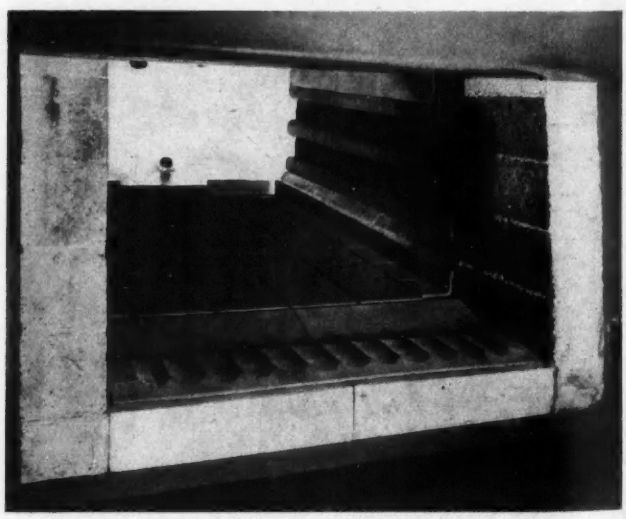
A number of improvements have been incorporated in the general design of the new "RS" furnace. As illustrated herewith, the external surfaces are smoothly contoured, with radiused corners and edges, and a paintwork finish. The front of the furnace is sloping. The door-operating gear, with its counterbalance weights, is now housed inside the furnace casing, which also encloses the transformers, contactor panel and ancillary equipment; access to these assemblies is gained through quickly detachable panels. The door lifts vertically and is self-clamping against the sloping front of the furnace vestibule, providing an effective seal against heat and atmosphere losses. A lever at the side of the furnace is used to raise and lower the door.

Another improvement is in the design of the hearth as shown in our second illustration: instead of being a single metal plate the hearth now consists of a number of small interlocking plates fitting together to form a single unit or a divided plate. To prevent buckling at the hearth plate, provision is made for expansion at the interlocking joints.

The furnace is nominally rated at 30kW from a standard three-phase electricity supply and heating is achieved by means of special very heavy section tape elements manufactured from a nickel-chromium heat-resisting alloy. The heating elements are arranged in the furnace



"RS" heat-treatment furnace with sloping front and vertical lift door



Heating chamber of the "RS" furnace, showing the jointed hearth plate and heating elements supported in slotted bricks in one of the side walls

roof and the side walls and below the furnace hearth plate so as to give temperature uniformity. The heating elements are mounted in slotted bricks so that any individual elements can be withdrawn easily and quickly from the furnace without disturbing any brickwork.

Automatic temperature control equipment is provided with the furnace. The temperature control instrument is an indicating instrument and operates in conjunction with a triple-pole magnetic contactor unit; it is mounted in a steel panel built on to the side of the furnace casing, while the remainder of the furnace electrical equipment, such as switchgear and transformer, is mounted below the furnace behind detachable panels.

A special atmosphere control system with the necessary valves, interconnecting pipework and burners is built into the furnace, town's gas and air being fed into a small combustion chamber located below the furnace vestibule. A removable plug at the side of the furnace gives access to the combustion chamber so that periodically it can be cleaned out without disturbing the main brickwork. For applications where a controlled atmosphere is not required and to make the equipment suitable for the class of work for which the "RP" furnace is generally used, the "RS" model is supplied with an additional heating element on the door and without the "certain-curtain" arrangement.

We learn that, for users who are concerned with the heat-treatment of smaller components and lower outputs, a smaller furnace of 20kW nominal rating is also being introduced. It will conform to the same general specifications as that of the 30kW unit, but as the hearth will be of smaller dimensions and, therefore, less liable to distortion, the jointed hearth plate will not be incorporated; instead, the hearth plate will consist of two single plates loosely butted together.

Universal Swaging, Wiring and Jennying Machine

THE universal swaging, wiring and jennying machine we illustrate on this page has recently been added to the sheet metal working equipment made by F. J. Edwards and Co., Ltd., 359, Euston Road, London, N.W.1. The machine is designed to handle up to 14 gauge sheet steel, and is supplied with twelve pairs of rollers for swaging, beading, wiring and tucking, jennying, joggling and necking work. Special rollers are also available for flanging, crimping and beading,

Universal machine for swaging, wiring, jennying, beading, and flanging, capable of working sheet metal up to 14 gauge

bottom closing and panning down operations if required.

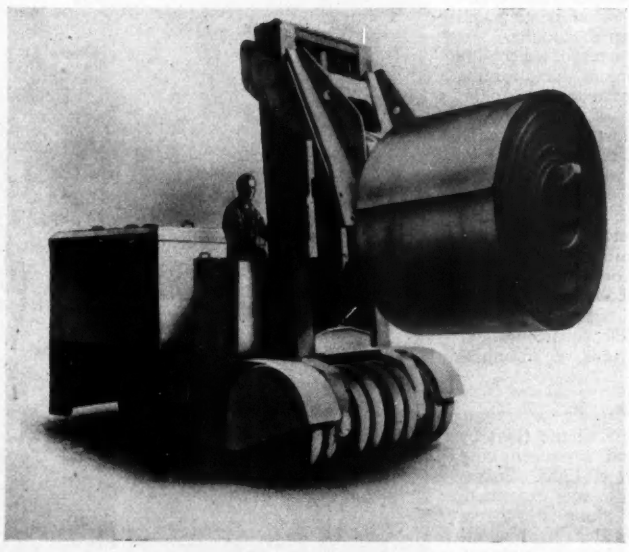
The machine is driven by a 1½ h.p. motor through gearing totally enclosed in the fabricated sheet steel body. The spindles have a working speed of 15 r.p.m. The top shaft is spring balanced and the position of the roller is set by means of a capstan screw on the top of the head. Horizontal adjustment for alignment of the rollers is made in the lower spindle assembly, which is locked by two hand-levers.

The gap depth is 14½in and the gauge fitted is designed to enable narrow strips as well as large cylinders and sheets to be worked. For convenience in operating, a movable remote control foot unit is fitted, and through this foot control, the rollers can be driven in either direction continuously or intermittently.

Heavy-Duty Fork Lift Truck

WE are informed by Mechanical Handling Equipment (Great Britain), Ltd., 7, Chesterfield Gardens, Curzon Street, London, W.1, that it has been appointed distributor in this country for the heavy-duty fork lift trucks made by Maschinenfabrik Esslingen, of Germany. This firm makes electric battery and diesel-engine-driven fork lift and ram trucks of 10 and 15 tons capacities. One of the 15-ton battery-driven ram machines illustrated below is designed for a useful load of 15 tons at 37½in load centre, and has a normal height of lift to 8ft 6in above ground level.

It is built upon a heavy steel plate welded frame with cast steel uprights supported at the front on two driving axles and at the back by



15-ton capacity, battery-driven fork lift truck

an oscillating steering axle with a ball-mounted turning ring. Each of the driving axles has four disc wheels fitted with solid rubber tyres, and is driven by a series wound d.c. motor with a one-hour rating of 6kW. A hydraulic brake acts on the two transmission systems and the steering wheels.

Power is supplied by a 600Ah 150V battery, which is stated to be adequate to operate the truck over a distance of about 20 miles or for about 8 hours working without need for re-charging. When unloaded the truck can be driven at speeds up to about 4 m.p.h., and when loaded about 3 m.p.h. It has a cam-actuated series controller with six speeds forward and reverse, and five electric braking stops with starting resistance. A motor-driven hydraulic fork lifting mechanism has a lifting speed of about 5ft per minute loaded.

If required, the truck can be fitted with a diesel-electric drive, in which a 75 h.p. engine drives a 48kW d.c. generator.

Indian Engineering News

(By Our Indian Correspondent)

Indian Automobile Industry

During 1947–48 India imported 35,414 automobiles, of which 23,197 were cars, mainly from the United Kingdom and United States. In 1953, six years later, the imports were running at a yearly average of about 9600 vehicles. In the intervening period assembly plants had been put up in the country, all of them in collaboration with foreign manufacturers, many of whom had provided both technical and financial assistance to indigenous industrialists. The drop has been attributed to the fact that the initial post-war years saw the replenishing of the considerable wartime backlog, which by 1950 had been responsible for the import of just under 100,000 vehicles. It is now estimated that the country's annual requirements are about 17,500 vehicles, consisting of 7500 small cars, 2500 big cars and 7500 trucks for both civil and military use. The Government has now formulated a long-range policy for manufacturing the whole number at home; by the end of 1956 it is proposed to reduce the imported components to less than 50 per cent.

Because of this policy, firms which were engaged purely in the assembly of vehicles had to shut down, for they were unable to submit approved programmes of manufacture. General Motors of India and Ford Motors of India, the two largest of such firms, have now wound up their operations. The other smaller assembly firms are in the process of doing so, leaving in the field the following four firms with approved manufacture programmes: Hindusthan Motors, Ltd., Premier Automobile, Ltd., Standard Motor Products of India, Ltd., and Automobile Products of India, Ltd. Of these, the first three had made some progress towards manufacture and the fourth one has so far not succeeded in keeping to its schedule and may be forced to close down. Hindusthan Motors will be making Studebaker (big car and medium truck) and a model known as "Hindusthan 14," which is the Indian equivalent of Morris "Oxford" of Nuffield Motors. Premier Automobiles will be making Dodge, DeSoto and Plymouth (big cars) and Dodge, DeSoto and Fargo trucks. Standard Motor Products will be manufacturing Standard "Vanguard" (medium car). Besides this programme for big and medium cars, the Government has also approved a similar planned programme for small cars, of which "Morris Minor" will be made by Hindusthan Motors, "Fiat 1100" by Premier Automobiles, and "Standard 8" by Standard Motor Products of India. All these programmes which are now being implemented are for a period of three years.

Recently Tata Engineering and Locomotive Company, Ltd., announced a programme for the manufacture of Mercedes-Benz diesel trucks and engines in collaboration with Daimler-Benz, of Germany. These trucks can develop a maximum of 108 b.h.p. and have a gross vehicle weight ranging from 14,770 lb to 18,750 lb. The scheme contemplates the manufacture of all the components of the vehicle within a period of four years, after which no components will be imported. The scheme envisages an initial capital expenditure of Rs. 4 crores (£3,000,000), of which Daimler-Benz will be investing one-fifth. The Tata Company already possesses a modern plant at Jamshedpur, Bihar.

Alcoa Building in Pittsburgh

(*By Our American Editor*)

The recently completed Alcoa Building in Pittsburgh, Pennsylvania, is a representative example of a new method of lightweight structural design now being applied to skyscrapers in America. The 410ft high, thirty-storey structure contains 310,000 square feet of useful floor space above the ground floor, yet required only 6000 tons of structural steelwork. It is said to be the lightest office building of its size ever built, its low weight being due principally to the extensive use of aluminium and other light materials in its construction. All exterior walls of the building are made up of 6ft wide, 12ft high and ¼in thick stamped aluminium sheet panels which are bolted to angles on the spandrel beams and are backed by aluminium lath and lightweight concrete.

THE Alcoa Building in the Golden Triangle district of Pittsburgh is of interest to architects and engineers on account of various unconventional methods adopted in its design and construction. In planning this aluminium-sheathed skyscraper, which houses its administrative offices, the Aluminum Company of America admittedly wished the structure (Fig. 1) to demonstrate both standard and new applications of aluminium and aluminium alloys in building construction. The structural steelwork of the building is fireproofed with foam concrete, which was also used for floor slabs in areas carrying mechanical equipment. The remainder of the flooring is of cellular steel panels surfaced with concrete fill and plastic tile or carpet, and fireproofed beneath with " Perlite " plaster. The exterior walls are thin, stamped aluminium alloy panels bolted to angles on the spandrel beams, and backed up with 4in of " Perlite " concrete sprayed on slotted aluminium lath and reinforcing bars. The ceilings are made up of aluminium radiant heating and cooling panels, designed to provide all the winter heating and half of the summer-time sensible cooling. Air for ventilation purposes and the rest of the cooling is distributed through aluminium ducts leading to ceiling diffusers. All electrical wiring, conduit and sector busses, and most of the piping are also of aluminium. The low weight of the building is illustrated by a comparison of its structural steel requirements with those of some of the neighbouring buildings of conventional masonry construction. The Alcoa building, containing 310,000 square feet of rentable space above the ground floor, contains only 6000 tons. In contrast, the thirty-eight-storey Gulf building, with 304,000 square feet of floor area, required 11,500 tons, and the older twenty-four-storey Oliver building, with 317,000 square feet of rentable area, needed 9000 tons of structural steel in its frame.

Structural Steelwork

Preliminary foundation work at the 100ft by 192ft building site comprised seventeen core borings extending to a depth of 120ft. Subsequently, the centre of the site was excavated, leaving a protective berm along the street boundaries. In the excavated area, small sheet-pile cofferdams were driven through sand and gravel and poor shale down to good rock, which was found at depths of up to 90ft below street level. After the cofferdams were excavated, concrete piers up to 70ft in height were built to support the building columns. All the foundation piers were designed for a maximum allowable bearing stress of 22 tons per square foot. On completion of the piers, a concrete slab was poured in the central area of the site. Sheet-piling was then driven around the lot boundaries and braced against concrete blocks anchored in the slab. Next, the berm was dug out, and the exterior piers were built. This method of construction eliminated bracing extending across the site and thus kept the centre of the site open for erection of the steelwork. In the excavated space below street level, there is a sub-basement, which now contains storage rooms and part of the air-conditioning equipment ; there also is a first basement above, which has service and locker facilities. The latter will also shortly become the terminal of an underground pedestrian tunnel connecting with the Pittsburgh Parking Garage, which is now under construction below the adjacent Mellon Square. Pedestrians will be able to ride on a moving stairway from the first basement to the ground floor, where shops and lifts are situated.

The steelwork framing of the building was erected in about six months (Fig. 2). To meet the close tolerances required for the installation of the exterior wall panels, the steel erectors plumbed the columns to within ¼in all the way up to the top level. Strong wind bracing connections were installed at every floor, because the tower is 410ft tall yet only 64ft wide. The column spacing varies but is mostly 20ft along the exterior of the frame. Floor construction and fireproofing work followed closely behind the erection of the steelwork. Lightweight foamed concrete was used in the construction of the floor arches in the service core of the building, and for fireproofing of all columns and spandrel beams. Keeping up with the riveters, ironworkers placed cellular light-gauge steel decking rapidly in the office areas, thus providing a working deck immediately. The decking, which contained electric and telephone wiring in its cells, was covered with a 2½in thick stone concrete fill and later was finished with plastic tile or carpet. The underside of the decking was fireproofed with a 1in layer of " Perlite " plaster on metal lath.

Building materials were brought up to the various floors on four hoists placed on the outside of the building. Before the walls were put in, the hoists were tied to the structural steel frame. After the wall panels were erected, pipe braces and wire guys were substituted for the ties. This new bracing was passed through window openings and held by U-bolts anchored to steel floor beams. Materials raised by the hoists then were brought into the building on ramps that passed through the window openings.

Wall Construction

The most striking application of aluminium in this structure is in the exterior treatment, and the method of curtain wall construction is already being followed in several later American office buildings. The entire building is sheathed in a continuous run of aluminium panels which were stamped out on a large hydraulic press. The

Fig. 1—The Alcoa Building in Pittsburgh. This 410ft high, thirty-storey structure contains 310,000 square feet of useful floor space, yet used only 6000 tons of structural steel. Aluminium panels are used for all external walls

Fig. 2—Completed structural steelwork

individual panels are 6ft wide, 12ft high and ¼in thick. The top half of each panel contains a 4ft 2in by 4ft 7in cut-out for the insertion of a reversible, vertically pivoted window. The bottom of each panel is depressed into an architecturally pleasing, inverted pyramid pattern 6½in deep. While providing some rigidity to the aluminium skin, the pyramid design was mainly specified for æsthetic reasons, since the panel, if desired, could have been fabricated in almost flat form to save 6in or more of wall thickness. All the panels were fabricated at the works of the Pullman Standard Car Manufacturing Company in Hammond, Indiana.

After being stored on each floor of the building until ready for installation, the panels were erected from within the structure (Fig. 3), thus eliminating the need for scaffolding. Heavily galvanised steel angle brackets were bolted to anchors

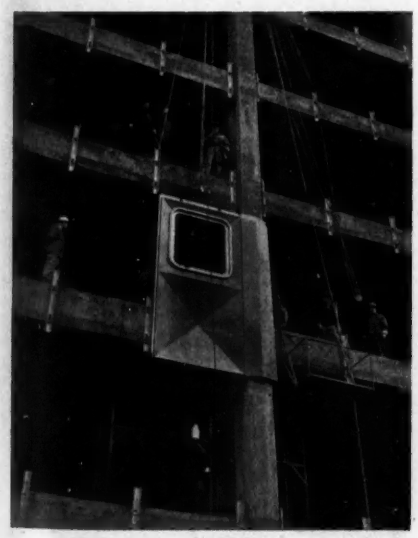


Fig. 3—Installation of aluminium wall panel

welded to the spandrel beams, to receive the panels. After the panels were shimmed and bolted to the brackets the joints required no additional taping or caulking ; the exterior thus requires no further maintenance. The flanges of adjoining panels are designed with a labyrinth (Fig. 4) to prevent penetration of rain; infiltrating air must change directions four times before being arrested at the secondary return flange. Smaller 27in wide panels, extending from floor to floor, cover the fireproofed structural columns spaced generally at 20ft intervals around the periphery of the structure. The metal panel is totally separated from its back-up, the dimension of the intervening space varying from 8in at the panel edge to 1½in at the apex of the pyramidal impression ; through this space, circulating air helps to evaporate any condensation that may form. Once the skin was properly anchored a slotted aluminium lath was installed to serve as

the Pittsburgh Building Code requires only a two-hour fire rating for exterior walls of commercial buildings, this curtain wall has satisfactorily passed a four-hour test. Experience has shown that two erection crews of five men each were able to enclose the structure with the aluminium skin in one month's time. Each spray crew for the application of the " Perlite " concrete included four men ; three such crews were able to erect the back-up walls at the rate of 2½ storeys per week. It has been estimated that compared with conventional masonry wall construction, the aluminium panel wall permitted a saving of some 10,000 tons of structural steel in the framework.

At the time of erection each wall panel contained a vertically pivoted, aluminium frame window measuring 4ft 2in by 4ft 7in ; the sash was double-glazed after each panel was in place. As the window pivots through 360 deg.,

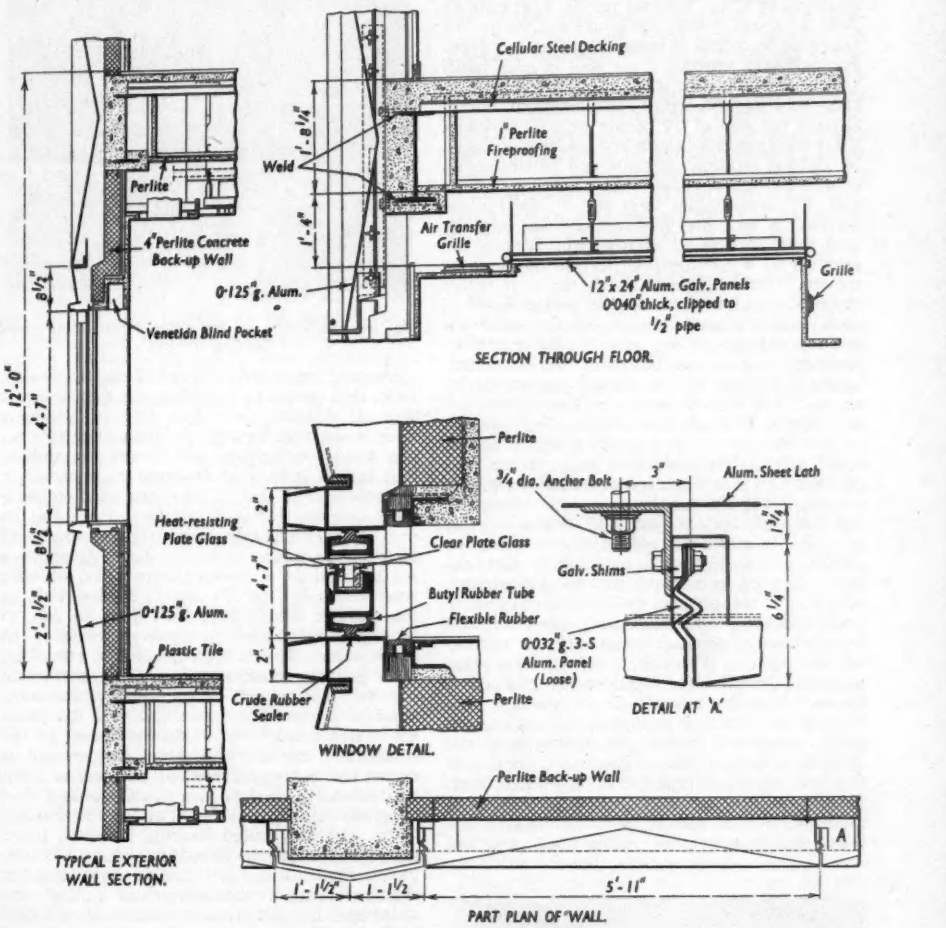


Fig. 4—Wall and floor construction details

a catcher screen for spraying on a lightweight " Perlite " concrete back-up. A maximum of five passes of the plastering machine was required to build up a 4in thickness of back-up. When the concrete had cured, a 1in plaster coat was applied to metal lath furred ¾in from the wall.

All exterior aluminium panels were anodised, and the presence of a 5 per cent silicon-bearing, aluminium alloy surface liner material gives them an iridescent, grey appearance without the use of pigment or dye. The aluminium skin alone will successfully resist a wind load of 30 lb per square foot with a safety factor of two. The total weight of the curtain wall is approximately 34 lb per square foot ; the skin weighing 2¼ lb per square foot, the 4in concrete back-up 22 lb per square foot, and the furring and plaster about 10 lb per square foot. The " Perlite " concrete aggregate in the back-up and the two air spaces provide the only thermal insulation in the wall. Tests have shown that the curtain wall has a coefficient of heat transfer of 0·14 ; it is believed that this factor will be even lower after the walls have been completely cured. Although

it can be washed from within the building, (Fig. 5), thus greatly reducing the hazard associated with the cleaning of sky-scraper windows. To simplify further the cleaning task all corners are rounded. A butyl-rubber tube which completely surrounds the window is inflated by compressed air to a pressure of 22 lb per square inch to ensure weather tightness. The windows are normally kept closed, except when they have to be turned to be cleaned. To open them for cleaning, window washers inside the building unlock them with a key and deflate the rubber gasket. After closing the windows the washers use a portable compressor to inflate the gasket. The exterior light of the double glazing is ¼in heat-absorbing, glare-reducing plate glass, and the interior light is ¼in clear plate glass. Although the exterior green-tinted glass reduces glare from the sun's rays on the inside of the building, it was also selected for its compatible appearance with the surrounding grey aluminium. Standing at the first interior column line and looking out of a window, the observer is unaware of any green colour in the glass ;

there is, however, a small tinted area noticeable on the ceiling near the exterior wall.

Heating and Cooling System

One of the most important innovations employed in the construction of the Alcoa Building is the use of overhead heating and cooling panels mounted in the ceilings. This design eliminates all radiators, pipes and under-window air conditioning units which are usually placed along the outer wall of conventional American skyscrapers. Practically all areas of the building are heated, and partially cooled, by the aluminium-panel, radiant ceiling. Below the 1in "Perlite" plaster fireproofing for the cellular steel floor, 6ft by 12ft grids of aluminium tubing are supported by a turnbuckle levelling system. Depending on the season, hot or cold water is circulated through this system of tubing. The welded grids are composed of ½in diameter aluminium tubes, spaced at centre distances of 12in. Radiant panels, 12in wide by 24in long and 0·40in thick, are clipped to the ½in tubes by means of integral, continuous grips. For acoustic reasons, 9 per cent of each panel area is perforated and a ¾in semi-rigid blanket of glass fibre rests on top of the aluminium tubing. Seventy per cent of the ceiling area is covered by the radiant panels while the remainder is occupied by lighting fixtures, diffusers and plaster soffits containing access panels. The lighting fixtures and diffusers actually form part of the radiant surface, as they are in direct contact with the grid tubes. Such an arrangement permits the removal of a considerable portion of the heat created by the lighting fixtures before it enters the room. A mill finish applied on the inside of each panel produces only a 5 per cent emissivity and resists radiation upwards; to the underside, however, two coats of paint were applied, giving a surface with a 92 per cent emissivity to direct radiation downward. The distribution of water is through horizontal mains, situated in the corridor ceiling, and through branches which extend to the individual grids. It has been estimated that as there are no radiators, piping or peripheral air conditioning units along the exterior wall, approximately 15,000 square feet of useful floor area was gained.

The principal source of cooling and dehumidification are two electric-motor-driven, centrifugal compressors of 560 tons capacity each, operating with condensing water supplied by aluminium cooling towers situated on top of the building. This central refrigeration plant generates chilled water, which is then pumped to the central station primary air conditioning units as well as to local interchangers serving the panel systems. Steam purchased from the Allegheny County Steam Heating Company is the basic source of heat and is distributed to all blast coils in the central station air conditioning units and is also used to generate primary hot water which is pumped to the local heat exchangers. The primary air is conditioned in four central air conditioning systems (one in the basement, two on the fourteenth floor, and one at the top level) which provide air at a temperature of 54 deg. Fah. all the year round. This air is humidified in the winter or dehumidified in the summer and is circulated through a central shaft to the secondary fan units situated on each floor. The primary air comprises 50 per cent outdoor air and 50 per cent return air which is regenerated by means of activated carbon and is electrostatically filtered. Each floor is served by one secondary fan unit, which mixes the primary air at 54 deg. Fah. with an equal amount of return air and then delivers it to the floor. As the room temperatures vary between 70 deg. and 80 deg. Fah., depending on the prevailing outdoor temperatures, the air discharged by the secondary fans will vary from 62 deg. to 67 deg. Fah., thus providing a cooling effect at all times. The air distribution system for an individual floor is not zoned except for the corner rooms; here local booster coils and air volume modulation permit individual temperature control.

Fig. 5—Vertically pivoted window being cleaned

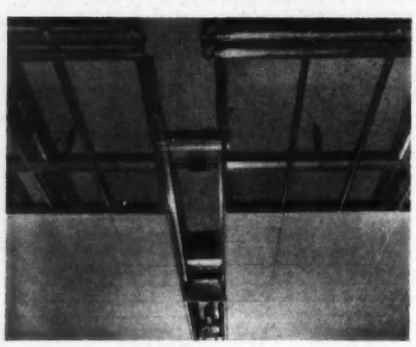


Fig. 6—Installation of perforated ceiling panels and lighting fixtures

Each floor is divided into four panel zones—three exterior and one interior. Each has its own heat exchanger, circulating pump and distribution piping system. Zone thermostats are situated in a representative office of each zone and reset from 70 deg. to 80 deg. Fah. as the outdoor temperature rises from 70 deg. to 95 deg. Fah., controlling the temperature of the panel water. This is accomplished by admitting either primary chilled or primary hot water to the zone heat exchangers. To prevent condensation a safety control prevents chilling of the panel water temperature below the dew point of the conditioned areas. The panel temperature is under full automatic control and varies from approximately 60 deg. Fah at full cooling load to approximately 100 deg. Fah. at full heating load. For accelerated heating, however, panel temperatures may be raised as high as 140 deg. Fah. Due to the favourable heat transfer characteristics of the aluminium ceiling, the water temperatures are only a few degrees higher or lower than the actual surface temperature of the panel. The small mass and the good conductance of the aluminium ceiling also result in an immediate response of the panel temperature to the call of the thermostat.

The Alcoa building is the first large American office building to use an electric wiring system comprising only aluminium. The interesting aspects of the electrical distribution system include (1) the exclusive use of aluminium conductor; (2) the exclusive use of rigid aluminium conduit; (3) the use of dual low-reactance riser busses; (4) use of aluminium lighting fixtures, designed as an integral part of the ceiling panel heating and cooling system; and (5) a lighting system (Fig. 6) that can readily be modified to meet changing office arrangements and provide a high lighting level of 35 to 50 foot-candles intensity. Of particular interest is the low reactance busbar (Fig. 7) of extruded aluminium. Two of these busses rise vertically through the building core and electricity is tapped from them at every floor. Each bus can carry 4000A 208V, three-phase, alternating current at 60 c/s. Because of their triangular shape and design it has been found that higher voltage regulation is possible than with the same amount of metal arranged in the form of the flat conventional busses. An advantage of the use of dual riser busses is that either riser can be switched off and isolated from the other by placing an extra heavy rubber curtain between the two. This makes it possible for electricians to service either bus without shutting down the supply.

The building incorporates many new and hitherto untried applications of aluminium in the plumbing field. About 60 per cent of all piping in the structure is aluminium. It is used, for example, for all domestic water supply piping, risers to toilet rooms, and for many of the valves and fittings in the network of plumbing installations throughout the building. Anticipating the day when aluminium piping may become useful in all phases of plumbing, the owners specified aluminium pipe to be used wherever practical and economical. A "sacrificial" aluminium pipe fitting is used throughout the building where aluminium and copper pipe are used in combination. For example, aluminium pipe ends just before flanged water valves on many fittings. At such junctions a special gasket is placed between flanges and around bolts, and this gasket acts as a barrier to electrolytic corrosion at the joint. Furthermore, in such connections, a 13in long, thick-walled section of almost pure aluminium pipe is inserted between the valve and the dissimilar metal pipe. Aptly named a "sacrificial" joint, it attracts electrolytic current away from the aluminium and dissimilar metal pipe and thus protects them from corrosion. There are more than 650 of these protective pipe inserts in the building, all being accessible for easy replacement when necessary. The aluminium pipe connections in the plumbing system are either welded by the "Heliarc" method or have flanged connections. Piping work in the building was accomplished without undue difficulty, in spite of the fact that the building is the first one in America to utilise aluminium piping on such a large scale.

The building is served by one freight and fourteen passenger lifts arranged in two banks. A bank of six cabs, rated at 3500 lb each, stops at all floors between the ground floor and the fifteenth floor. A second bank of eight cabs, rated at 2500 lb each and designed to operate at 1000ft per minute, stops at all floors from the fifteenth to the thirtieth. One lift in the high-rise bank is being used as an auxiliary service lift, except during peak traffic periods. This, and the freight lift, also serve the first basement and sub-basement of the building.

Harrison and Abramovitz, of New York City, acted as architects, and Edwards and Hjorth, of New York City, as consulting structural engineers in the design of the building. The George A. Fuller Company was the general contractor, and the structural steelwork was fabricated and erected by the American Bridge Division of the United States Steel Corporation.

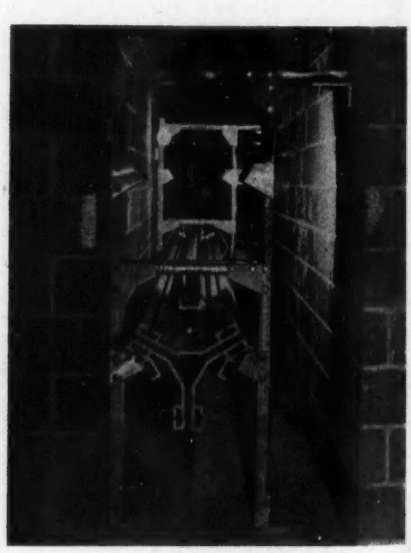


Fig. 7—Installation of low-reactance riser bus

Industrial and Labour Notes

Report on the Training of Supervisors

In the early part of last year a committee was set up by the Minister of Labour to inquire into the training of supervisors in this country. Its membership included representatives of the voluntary associations concerned with supervisory training, the British Employers' Confederation, the Federation of British Industries, the Trades Union Congress, the Ministry of Labour and the Ministry of Education.

Last week the report of this committee was published by H.M. Stationery Office (price 2s.). The report suggests that a great deal more needs to be done within industry and outside it to provide more facilities for the training of supervisors and to ensure that those facilities are used to the best advantage. In its examination of the position, the committee estimated that the number of supervisors in industry throughout the country was about 300,000 and that well over 10,000 new supervisors would be needed each year.

The principal conclusions reached by the committee are that the main responsibility for the training of supervisors must be accepted by management; that there is need for more training related to the day to day work of the factory supervisor, and that there is also need for an examination by industry of the status of the supervisor and recognition of his importance as a member of the management team. The report goes on to say that the needs and conditions of industry are "too various" to enable the committee to produce a cut and dried scheme suitable for all occasions. The committee urges, however, that managements should consider the training needs of supervisors under the following five general headings: technical or job knowledge; company organisation, policy and practice; background and general knowledge; handling and instruction of subordinates and team leadership, and methods improvement and work study. The report emphasises that the training should be continuous and practical; in particular, it is suggested, local employers, technical colleges and others should co-operate more closely in providing suitable courses and industry should help by providing instructors for the courses. On the need for general recognition of the foreman, as a member of the management team, the committee says that unless his position in the undertaking is such that he can use and develop the capabilities and skills which he can acquire from training, the best designed course intended to qualify him for the full status of his post will be of little value to him.

Iron and Steel Production

In these notes in our issue of July 9th we referred to a survey of progress in the iron and steel industry, during the first six months of this year, which was made recently by the British Iron and Steel Federation. At that time the final production figures for the month of June had not been issued.

These figures have now been given by the Iron and Steel Board. The production of steel ingots and castings in June averaged 371,700 tons a week, which represented an annual output rate of 19,328,000 tons, compared with an annual rate of 17,559,000 tons in June, 1953. During the first six months of this year steel production was at an annual rate of 19,048,000 tons, against a rate of 18,074,000 tons over the corresponding period of last year. Pig iron output in June averaged 233,200 tons a week and was thus at an annual rate of 12,129,000 tons. The annual rate of pig iron production over the first six months of this year was 11,964,000 tons, compared with a rate of 11,102,000 tons in the corresponding period of 1953.

European Steel Production

The United Nations Economic Commission for Europe shows in the latest issue of its *Quarterly Bulletin of Steel Statistics* that crude steel production continued to increase in most countries in Western Europe during April and May. The *Bulletin* comments that "production continued to break all records in the United Kingdom, remained at record heights in Italy and the Netherlands, and improved in Western Germany, France, Belgium, the Saar and Luxembourg." In the U.S.A., steel output dropped to 79 per cent of the 1953 level in the first four months of this year, but showed an upward trend during May. Steel production in Japan in the first four months of this year "continued at a record level."

It is stated that exports of finished steel from Austria and Western Germany increased slightly in the first quarter of this year, compared with the last three quarters of 1953, those from Belgium, Luxembourg and France declined a little, while exports from the Netherlands and the United Kingdom remained practically unchanged. Steel import figures of France, Western Germany, Italy and the Netherlands each showed some increase over the same period, imports into Sweden and Switzerland remained stationary, and those into Belgium, Luxembourg and the United Kingdom declined. The figures of foreign trade in steel-making materials for the first quarter of the year, compared with the first quarter of 1953, indicate that whilst exchanges of coke have declined, the trade in scrap has intensified. It is suggested that this trend is accounted for by the fact that, owing to the decreased activity of the steel industry in most of the European Coal and Steel Community countries during the first quarter compared with a year earlier, a greater proportion of the coke requirements has been met from domestic sources, and the temporary surplus of scrap which has arisen has been exported to such destinations as the United Kingdom and Italy, where steel production has increased. Similarly, the *Bulletin* says, the figures for trade in iron ore reflect the lessened activity of the Western German iron and steel industry and the increasing activity in the United Kingdom.

Industry in Scotland

A debate on industry and employment in Scotland was concluded in the House of Commons on Monday evening. It had been opened on Thursday of last week when the Secretary of State for Scotland, Mr. James Stuart, said that industrial production in Scotland so far this year had been about 5 per cent greater than during the corresponding period last year.

Much of the increase, Mr. Stuart explained, had derived from the engineering, vehicle and allied trades which were now producing about 8 per cent more than in the comparable period of last year and more than in any similar period in earlier years. In mining and quarrying, however, Mr. Stuart stated, production still tended to remain, on the average, very close to the 1948 level. Steel production in Scotland last year was 10 per cent higher than in 1952, and supplies of steel plate now seemed to be equal to current demands. About shipbuilding, Mr. Stuart continued, the picture was not so satisfactory. Whilst it was true that more tonnage was completed last year than in 1952, the figure was not so high as in 1951. Unfortunately, there was now a lack of new orders which caused anxiety. The bigger yards had orders for two years ahead, but some of the smaller yards which were busy at present, were looking out for future contracts.

In a contribution to the debate on Monday, the President of the Board of Trade, Mr. Peter Thorneycroft, gave some particulars of factory development and extension in Scotland. He said that negotiations were proceeding for a new Government-financed factory near Belshill, occupying 100,000 square feet, for an American electrical engineering firm. At the end of last year, factories administered by Scottish Industrial Estates were employing about 60,000 workers, which was 7000 more than at the end of 1952. Of the 350 factories administered by Scottish Industrial Estates, only one of any size at all was vacant, which, Mr. Thorneycroft suggested, was a very satisfactory position to contemplate at the present time. He added that in 1952, Scotland had 13 per cent of all the factory approvals given by the Board of Trade, and in the second quarter of this year the factory buildings approved were more than double those for the first quarter.

Coke Oven Workers' Strike

On July 5th about 300 coke oven workers employed by the Steel Company of Wales, Ltd., at Margam, began an unofficial strike over a dispute on bonus rates. The stoppage continued throughout last week, despite the efforts of union officials to induce a return to work, and by the end of the week the steel output of the company's Abbey and Port Talbot works was seriously affected. Following a meeting of the strikers on Monday last, which was attended by representatives of the Iron and Steel Trades Confederation, it was stated that a return to work had been decided upon so that negotiations over a claim for a production bonus could be started. The Steel Company of Wales, Ltd., said that it was hoped that steel ingot production, which had been halted as a result of the strike, would be resumed by the end of this week.

Ministry of Materials

On Thursday of last week the Prime Minister, Sir Winston Churchill, made a statement in the House of Commons about the Ministry of Materials. Sir Winston said that a draft order in Council dissolving the Ministry and transferring its remaining functions to the Board of Trade from August 16th had been laid before both Houses of Parliament.

That step had become possible, the Prime Minister continued, by the progress which had been made in bringing to an end public trading in industrial raw materials. Within the space of the last eighteen months or so the trade in lead, zinc, aluminium, copper, magnesium, hemp, sulphur, pyrites, tungsten, raw jute and cotton had been restored to private hands and the restoration of the timber trade had been completed. To dismantle these large and diverse trading structures, Sir Winston said, and to dispose of the terminal stocks had been a formidable operation. By the end of this financial year, however, the great bulk of the disposals would have been effected at fair market prices and, so far, without any serious disturbance to trade. Nearly 1,400,000 tons of the materials mentioned, excluding cotton, to a sales value of about £125 million would have been disposed of, including the transfer to reserves of substantial quantities of vital strategic metals.

The Prime Minister went on to say that the absorption of the Ministry of Materials by the Board of Trade would, of course, result in economies of administration, as reorganisation became effective. The functions to be transferred, however, although not extensive enough to justify any longer a separate department, were of great importance—the management and custody of valuable strategic stockpiles of materials, for example—and care would be taken to provide the staff needed for the efficient discharge of those responsibilities.

Summer School of Production Engineering

The Institution of Production Engineers has announced details of its fifth annual summer school of production engineering which is to be held at Ashorne Hill, near Leamington Spa, from August 25th to 29th. The school this year will be divided into two sections, one studying "Industrial Application" and the other "Education and Training." The lectures introducing the subjects for discussion will deal with practical training for the production executive; the value of examinations, and opportunities for craftsmen and their selection for promotion. Group discussions will be followed by joint sessions at which the collated reports of the groups will be considered by the lecturers.

Notes and Memoranda

Air and Water

MEMORIAL PLAQUE TO MR. GEORGE BALFOUR.—On Tuesday, July 20th, at Tummel Bridge power station, between Pitlochry and Loch Rannoch, Sir John M. Erskine, a member of the North of Scotland Hydro-Electric Board, unveiled a plaque to the memory of the late Mr. George Balfour, chairman of Balfour Beatty and Co., Ltd., and a pioneer of hydro-electric development in the Highlands.

FIRST FLIGHT OF "COMET III."—The de Havilland "Comet III" took the air for the first time on Monday, July 19th, for an eighty-five-minute test flight from Hatfield, Hertfordshire. The "Comet III" airliner has a longer fuselage than the earlier machine, and can accommodate up to seventy-eight passengers. Power is provided by four Rolls-Royce "Avon" engines, each of which gives 10,000 lb of static thrust, and cruising speed will be at least 500 m.p.h. It is designed to fly at an all-up weight of 145,000 lb and to cover stage lengths of 2500 miles with diversion allowances. The de Havilland Company has calculated that 97,000 passengers a year could be carried over the Atlantic by a fleet of five "Comet IIIs"—nearly 20,000 passengers per aircraft.

LECTURE COURSE ON AIRCRAFT ELECTRICAL SYSTEMS.—A five-day aviation school to review aircraft electrical systems will be held at the Imperial College of Science and Technology from Monday to Friday, September 20 to 24th. The object of the school is to bring out the scientific principles underlying the design and application of all forms of equipment used in aircraft electrical systems. It is intended primarily for engineers who already have some experience in the design and application of aircraft electrical power equipment, and who might therefore be expected to contribute to the discussions. About an hour will be made available for discussion after most lectures: to keep these periods intimate and informal it is thought that the number participating should be limited to about sixty. The fee for the school, including lunches, refreshments, transport, &c., will be eight guineas. A limited number of single rooms in Imperial College Hostel is available for members of the school at 12s. 6d. per night. Breakfast at about 2s. 6d. and supper at about 3s. 6d. will probably be available in the nearby College Refectory. An opening address will be given by Sir Frederick Handley Page. The principal lectures will include an "Introductory Survey," by D. F. Welch, British Thomson-Houston Company, Ltd.; "Environmental and Functional Requirements," by M. Hancock, R.A.E., Farnborough; "Power Systems," by J. H. Rea, Rotax, Ltd.; "Brushwear and Vibration Problems," R. F. Sims, R.A.E., Farnborough; "Cooling Problems," by G. S. Hudson, R.A.E., Farnborough; "D.C. Machines," by B. Adkins, Imperial College; "Electrical Installation Engineering," H. Zeffert, Vickers-Armstrong, Ltd.; "A.C. Machines," W. Philipp, Rotax, Ltd.; "System Operation and Protection," K. J. Payne, British Thomson-Houston Company, Ltd.; "Switchgear," by A. Grieve, British Thomson-Houston Company, Ltd., and "Future Trends," by S. F. Follett, M.I.E.E., Ministry of Supply.

Miscellanea

COURSES IN CONCRETE TECHNOLOGY AT NOTTINGHAM UNIVERSITY.—During September, October and November a series of lectures will be given at Nottingham University on concrete technology. The course has been arranged by the University in conjunction with the Cement and Concrete Association; the lectures will be held on Wednesday afternoons, and will be supplemented by discussions and practical periods.

INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION.—At the recent annual general meeting of the British Internal Combustion Engine Research Association Viscount Falmouth, M.I.Mech.E., was re-elected president. Sir Harold Cox, M.I.Mech.E., F.R.S., Dr. S. F. Dorey, M.I.C.E., M.I.Mech.E., F.R.S., Major-General H. R. B. Foote, V.C., and Vice-Admiral (E) F. T. Mason, C.B., Engineer-in-Chief of the Fleet, were re-elected vice-presidents. Mr. G. W. Bone, Mr. J. Calderwood, Dr. A. R. Morcom and Mr. A. V. Wilkin were elected to the council.

N.P.L. LIAISON WITH INDUSTRY.—The application by British industry of results of research from the National Physical Laboratory is fostered by direct contact between the research workers at the Laboratory and individuals in industry, as well as by contributions to the scientific and technical press. It is felt, however, that much more could be done to bridge the gap between the research laboratory and industry. To meet this need Sir Edward Bullard, F.R.S., Director of the National Physical Laboratory, has appointed Mr. E. I. Brimelow and Mr. A. J. Garratt as liaison officers to work with industry. Mr. Garratt is a physicist and Mr. Brimelow is a metallurgical engineer.

TRAINING OF PROFESSIONAL ENGINEERS.—An illustrated booklet, entitled *The Training of the Professional Engineer* has recently been produced by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester. It is intended for final year students of universities and senior technical colleges. The booklet gives details of the company's college apprenticeship courses, which last for two years, and which include intensive basic training in manufacturing processes and experience in various departments, together with lectures, discussions and works visits. Part-time post-graduate studies at Manchester College of Technology and the Salford Royal Technical College are encouraged.

ENGINEERING MODELS AT THE INSTITUTION OF CIVIL ENGINEERS.—In an article under this title in our issue of July 2nd we gave the crest length of the Dokan dam, an arched structure now under construction on the Lesser Zob River in Iraq, as 115ft. The dam is a much larger structure than this figure indicates. The crest length, in fact, is 1150ft. Our apologies are due to the consulting engineers, Messrs. Binnie, Deacon and Gourley, and the contractors, Dumez-Ballot, of Paris.

INSTITUTE OF METALS.—The forty-sixth annual autumn meeting of the Institute of Metals is to be held in Switzerland from September 6th to 14th. The meeting will open in Zurich on Monday, September 6th, and on the following Saturday, September 11th, those taking part will leave for Montreux, from which town additional works and other visits will be made until the afternoon of Tuesday, September 14th. At the opening of the meeting on September 6th, in the Technische Hochschüle, Zurich, the 1953 Institute of Metals Platinum Medal will be presented to Dr. Georg Masing. The autumn lecture will be delivered on Thursday evening, September 9th, by Professor Dr. A. von Zeerleder on "Attempts to Improve Aluminium Reduction since Hérault and Hall."

VISUAL TRAINING AIDS.—The British Association for Commercial and Industrial Education has just completed the production of two visual training units with the help of the U.S.A. Foreign Operations Mission to the United Kingdom. Each training unit consists of a film, a film strip, an instructors' handbook, a set of illustrated leaflets and a wall chart. The titles of the units are "First Impressions" and "Supervise With Care." The film is shown first, after which discussion takes place while the film strip is shown to remind the group of outstanding incidents and recapitulate the main points. Illustrated leaflets are circulated to members of the group so that they have a visual and verbal record of the story. Wall charts are available to summarise the main points of the lesson.

"RUTHERFORD BY THOSE WHO KNEW HIM."—The Physical Society has now published the first five Rutherford lectures in book form under the title *Rutherford by Those Who Knew Him*. The lectures, all of which are reminiscent in character, have been reprinted from the *Proceedings of the Physical Society*. Those included are "Rutherford: Life and Work to the Year 1919, with Personal Reminiscences of the Manchester Period," by H. R. Robinson; "Rutherford: Life and Work After the Year 1919, with Personal Reminiscences of the Cambridge Period," by Sir J. D. Cockcroft; "Rutherford and the Modern World," by M. L. Oliphant; "Rutherford Memorial Lecture (1948)," by E. Marsden, and "Lord Rutherford: Manchester, 1907–19: A Partial Portrait," by A. S. Russell. Copies may be obtained from the Physical Society, 1 Lowther Gardens, London, S.W.7; price, members 5s., non-members 8s. 6d.

AUTOMATIC CONTROL AND COMPUTING.—It is announced that a new division has been formed at the National Physical Laboratory by the amalgamation of the electronics and the control mechanisms sections, and is to be called the Control Mechanisms and Electronics Division. The field to be covered by this new division is the automatic control of industrial, administrative and experimental operations and the development of techniques and equipment for data processing and computation. An industrial example of such mechanisms is the automatic control of machines producing precision components in large quantities. Not only are the operations speeded up but personnel can be released from the boredom of repetitive work. It is hoped that this trend will not be confined to the factory floor but that many routine office operations will also be carried out by suitable machines. The new division is represented on a small group formed to study this subject. The officer in charge of the division is Mr. R. H. Tizard, A.M.I.E.E.

Contracts

THE ENGLISH ELECTRIC COMPANY, LTD., has received an order for the supply of two 11kV, 10MW turbo-alternator sets for the Municipal Council of Georgetown, Penang. The consulting engineers for the scheme are Messrs. Preece, Cardew and Rider. The sets will operate at 400 lb per square inch and 800 deg. Fah., and the contract includes the supply of condensers and feed heating equipment. This plant is for the new power station, which is to be built on Penang Island to replace the old municipal power station at Prai on the mainland.

THE ENGLISH ELECTRIC COMPANY, LTD., has received an order from the Nova Scotia Light and Power Company for one 45MW, 3600 r.p.m. steam turbo-alternator set, complete with feed heating and condensing plant, for installation at the Water Street power station in Halifax, Nova Scotia. The turbine is designed for steam conditions of 900 lb per square inch gauge, 900 deg. Fah., at the stop valve, and for five-stage feed heating with a vacuum of 28½in at maximum continuous rating. The alternator is hydrogen cooled, generating at 13·2kV, three-phase, 60 c/s. The condensing plant is of cleanable twin shell construction and the five-stage feed heating scheme will comprise three low-pressure and two high-pressure feed water heaters.

THE GENERAL ELECTRIC COMPANY, LTD., has received a £2,000,000 order for the complete power station for the £20,000,000 iron and steel project of Colvilles, Ltd., at Motherwell. This contract includes the power-house building and associated civil work; four Babcock and Wilcox gas and oil-fired boilers of 125,000 lb per hour each; three 10MW turbo-alternators with Mirrlees Watson condensing and feed heating plant, feed pumps and auxiliaries, and two steam turbo-driven centrifugal blowers of 11,000 h.p. each, for supplying air to the new furnaces. The work also includes two ferro-concrete natural draught towers, each for cooling 1,200,000 gallons of water per hour; two pumps driven by turbines arranged to exhaust steam to process plant; 11kV switchgear for control of the alternators and feeders and l.t. switchgear and motors for auxiliaries, and the lighting installation.

Personal and Business

MR. F. HOBDAY has been appointed works manager of Semtex, Ltd.

MR. P. O. WYMER has been appointed press officer in the publicity division of Mullard, Ltd.

VOKES, Ltd., Henley Park, Guildford, states that its London office is now at 123, Victoria Street, S.W.1 (telephone, Victoria 4550).

MR. L. C. JARMAN, A.M.I.E.E., has been appointed group personnel officer of Metal Industries, Ltd., Victoria Station House, London, S.W.1.

MR. BERNARD C. LOVATT has been appointed chief engineer of The Parsons Engineering Company, Ltd., Town Quay Works, Southampton.

THE COLONIAL OFFICE announces the appointment of Mr. A. G. Smith, of Whitehaven, as an executive engineer in the Public Works Department, Nigeria.

INTERNATIONAL MEEHANITE METAL COMPANY, Ltd., states that, from August 1st, its office address will be Meerion House, 4, Downside, Epsom, Surrey (telephone, Epsom 3507).

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., Marconi House, Strand, London, W.C.2, states that its telephone number is now Covent Garden 1234.

W. CANNING AND CO., Ltd., Great Hampton Street, Birmingham, states that its Sheffield branch has been transferred to new premises at 1, South Parade, Shalesmoor, Sheffield.

MR. MAX DAVIES has relinquished his position as public relations officer of the British Iron and Steel Research Association on being appointed editor of *Petroleum Times*.

MR. S. ROBERTS has been appointed deputy managing director of Hoover, Ltd., in succession to Mr. F. H. Bunn, who has retired after thirty-three years' service with the company.

JOHN YUILLE (METAL WORKS), Ltd., Hillington Industrial Estate, Glasgow, S.W.2, states that it has extended its activities to include the manufacture of high precision tools and gauges.

LONDON TRANSPORT announces the appointment of Mr. L. A. M. Ginger, A.M.I.E.E., as assistant chief electrical engineer. Mr. H. Branton has been appointed assistant electrical engineer (generation).

MR. W. CASSON, M.I.E.E., has been appointed transmission design engineer of the British Electricity Authority. He succeeds Mr. F. J. Lane, M.I.E.E., who has been appointed deputy chief engineer (transmission).

MR. C. A. C. HILLYER, of the Willesden switchgear works of The British Thomson-Houston Company, Ltd., has been nominated president of the London branch of the Association of Mining and Mechanical Engineers.

GLOSTER AIRCRAFT COMPANY, Ltd., announces the retirement of Mr. W. G. Carter, F.R.Ae.S., from the position of technical director. Mr. R. W. Walker, the company's chief designer, has been appointed a director.

TEDDINGTON INDUSTRIAL EQUIPMENT, Ltd., Sunbury-on-Thames, has opened a Scottish area office at 134, St. Vincent Street, Glasgow (telephone, Glasgow Central 7935). The company has also opened a Northern district office at 31, Quay Street, Manchester.

THE YALE AND TOWNE MANUFACTURING COMPANY announces the following appointments at the British Materials Handling Division, Wednesfield: Mr. Kenneth V. Mason, assistant general manager, Mr. Douglas H. Outwin, sales manager, and Mr. G. F. H. Lefroy, works manager.

AIR CONTROL INSTALLATIONS, Ltd., Ruislip, announces the opening of a branch office in the Newcastle upon Tyne area, with Mr. N. J. Shergold as branch manager. For the present inquiries should be addressed to Mr. Shergold at 76, Holywell Avenue, Whitley Bay (telephone, Whitley Bay 23046).

THE DISTILLERS COMPANY, Ltd., Devonshire House, Piccadilly, London, W.1, and the Oronite Chemical Company, San Francisco, U.S.A., announced the formation of a jointly owned company entitled Orobis, Ltd., for which a plant is being constructed at Hull for the production of lubricating oil additives.

DOWTY GROUP, Ltd., Cheltenham, announces the following appointments: Mr. E. J. Nicholl, joint managing director of Dowty Equipment, Ltd., and managing director of Dowty Fuel Systems, Ltd.; Mr. F. J. A. Mangeot, director of Dowty Fuel Systems, Ltd.; Mr. R. C. Cussons, chief designer of Dowty Equipment, Ltd.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., states that it has purchased the factory and equipment owned and operated by Jowett Cars, Ltd., at Bradford, Yorks, subject to the approval of the Treasury and the shareholders of Jowett Cars, Ltd. It is announced that arrangements have been made to ensure continuity of Jowett's own production.

British Patent Specifications

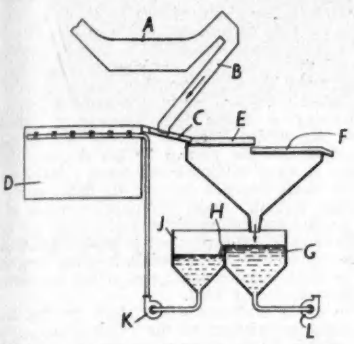
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

MINING ENGINEERING

710,948. June 14, 1951.—SEPARATION OF IMPURITIES FROM COAL OR OTHER MINERALS, The Coppee Company (Great Britain), Ltd., Coppee House, 140, Piccadilly, London, W.1, formerly of North West House, 119/125, Marylebone Road, London, N.W.1, and William Sansam, of the company's address.

The invention relates to the separation of impurities from coal or other minerals by methods which include gravity separation in a bath of a dense liquid medium constituted by a suspension of tailings or the like in a liquid. As shown in the drawing *A* indicates a high density bath separating coal, ore or the like of relatively large particle size. The medium used in the bath may consist of a suspension of tailings in water. The large coal leaves the bath through a chute *B*



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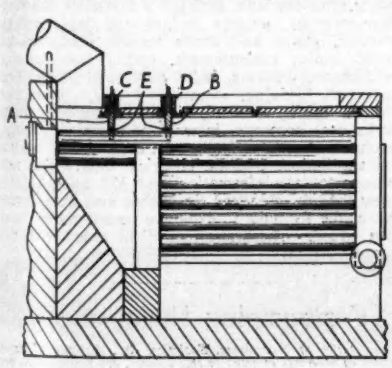
and flows into a launder *C* where it mixes with the water containing separated coal of relatively small size which has been separated out in a washer box *D*. The launder extends between the washer box and dewatering screens *E* and *F*. The separated coal usually leaves the washer box *D* mixed with an excess quantity of water and accordingly the relatively large and small particle sizes in the launder will be washed by the entrained water over the screens *E* and *F*. The excess of entrained water is ample to ensure that any tailings adhering to the large coal will be washed off. The water and tailings passing through the screens flow into the slurry basin *G*, the relatively clean water flowing over the weir *H* into a washery pump basin *J* from whence it is recirculated by the pump *K* back to the baum washer box *D*. The thickened liquid resulting from the settling of the tailings in the slurry basin *G* is delivered by the pump *L* to a suitable slurry treatment plant. After leaving the screens *E* and *F* the coal is graded by suitable classifying screens.—*June* 23, 1954.

STEAM GENERATORS

710,949. June 21, 1951.—WATER TUBE BOILERS, Stanley Payne, "Clovelly," North Street, Nazeing, Essex.

The primary object of the invention is to improve the efficiency of boilers by introducing a series of baffle plates in the flue space to permit the fuller



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extraction of the heat from the combustion gases while the construction of the baffles is such as to permit the flue to be readily cleaned. In the construction shown in the drawing, two baffle plates, *A* and *B*, are mounted in the horizontal flue space at the end adjacent to the vertical flue or chimney in transverse frames *C* and *D*, which extend across the boiler and rest at each end on the brick side wall. The baffle plates are preferably tapered section with the maximum thickness at the top, so that if any distortion under heat occurs along the lower edge it will not prevent their withdrawal when required from out of the boiler flue space. The lower edge of each baffle plate is provided with a series of spaced semi-circular recesses *E* corresponding to the flue tubes so that when a baffle is mounted in position it will be resting on the tubes and the effective depth of the baffle will extend down to approximately the centre. In operation the hot gases follow a sinuous path and their passage along the horizontal flue is slowed down to permit the maximum calorific value of the burning fuel to be extracted before reaching the chimney. Handles are provided on the top of each baffle to facilitate their removal when it is desired to clean the flue. A modified construction is also shown in the specification.—*June* 23, 1954.

BEARINGS AND SUPPORTS

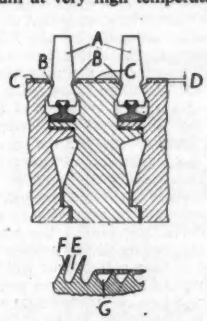
711,438. November 23, 1951.—PLAIN BEARINGS, The Glacier Metal Company, Ltd., 368, Ealing Road, Alperton, Wembley. (*Inventor: William Henry Tait.*)

The bearing liner comprises a steel backing having a thickness of 0·060in and a 70 : 30 copper-lead lining with a thickness of about 0·030in, and an elastic modulus of 12 to 13 million pounds per square inch, bonded to it. The layer is made in the usual way by forming from a blank of strip material in which the copper-lead is sintered on to the steel. The liner is then bored to reduce the total wall thickness to 0·080in. The liner is then cleaned and plated in the bore by any suitable method adapted to give a uniform coating of lead 0·001in in thickness. The lead coating is burnished to eliminate any porosity and then plated in a conventional fluoborate plating bath with a layer of nickel to a thickness of 0·0001in. This coating is cleaned and finally a coating of a tin-lead alloy containing 10 per cent of tin is deposited to a thickness of about 0·002in which, in a final boring operation, is reduced to about 0·001in, giving a total wall thickness of 0·0821in. The thicknesses of the various layers may vary within certain limits. Thus the thickness of the backing may range from 0·035in to 0·250in, the thickness of the copper-lead layer from 0·010in to 0·080in, the thickness of the lead layer from 0·0005in to 0·004in, the thickness of the nickel barrier layer from 0·00005in to 0·00015in and the thickness of the bearing facing of tin-lead alloy from 0·0005in to 0·005in, and preferably from 0·0015in to 0·0025in. The composition of the copper-lead layer and of the tin-containing alloy bearing surface layer may be varied and in place of nickel, any other suitable metal which is resistant to tin diffusion may be employed.—*June* 30, 1954.

GAS TURBINES

710,958. August 17, 1951.—STEEL ROTORS FOR GAS TURBINES, Maschinenfabrik Augsburg-Nürnberg A.G., Stadtbachstrasse 7, (13b), Augsburg 2, Germany.

This invention is concerned with steel discs or drums of an axial-flow, single-stage or multi-stage, turbine rotor which is designed to operate with driving medium at very high temperature, the rotor



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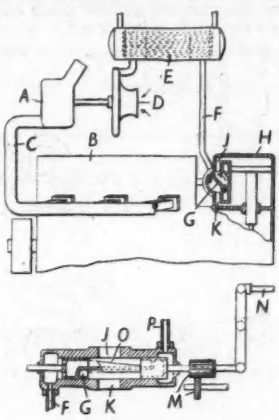
having blades consisting of ceramic materials. In the turbine rotor shown in the drawing, the ceramic blades *A* are arranged in peripheral grooves *B*. The heat barrier layers in front of and beyond or between the rings of blades on the surface of the disc or drum are designated by *C* and their thickness by *D*. Annular grooves *E*, as shown in the lower view, are worked into the surfaces, the outer portions of the partitions *F* remaining between the grooves being bent over and thus forming cavities *G* which contain a stationary gas layer or through which the cooling air is passed. Modified constructions are also shown in the specification. The provision of the heat barrier layer is extremely simple and has the great advantage that loose screening elements, which are frequently very difficult to secure reliably to the rotor owing to the high speeds, are avoided.—*June* 23, 1954.

INTERNAL COMBUSTION ENGINES

711,342. February 15, 1950.—INTERNAL COMBUSTION ENGINES, Crossley Brothers, Ltd., Openshaw, Manchester 11, and Herbert Desmond Carter, of the company's address.

The invention concerns the means by which air is supplied to the cylinders of two-stroke and four-stroke cycle diesel engines. As will be seen from the drawing, *A* is the turbine driven by the exhaust gases from the engine *B*, and *C* is the exhaust gas manifold. The gas turbine drives a compressor *D*



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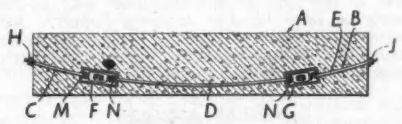
which draws air from the atmosphere and delivers it to a cooler *E* and a pipe connection *F* to a timing valve *G* and a positive displacement pump *H*, which delivers the air to the engine manifold. The timing valve can be constructed as shown in the lower view. *F* is the pipe leading from the air cooler *E* and the connections to the upper and the lower ends of the double-acting pump *H* are at *J* and *K* respectively. The delivery branch leading to the manifold is shown at *P*. The valve *G* is revolved by timing gears *M* from the engine crankshaft in the direction indicated by the arrow in the upper view, and it is also moved axially or longitudinally by the connection *N* from the engine governor. It has a tapered part *O* to regulate in accordance with the axial position of the valve, the duration of opening of the pipe *G* and the ports *J* and *K*. In the position shown in the lower view, air is passing from the pipe *F* to the port *J*, and air from the port *K* is passing to the engine manifold through the pipe *P*. By means of the valve the pump may be used as an air expander, a cooler or a freezer. The position of the valve is regulated so as to give optimum timing of the point of cut off in the intake stroke of the pump. It is claimed that the arrangement described is particularly advantageous with two-stroke diesel engines having a mechanically-driven positive displacement scavenge pump compressor, or charger, which may be a reciprocating piston, or Roots blower. An arrangement for a Roots blower is also shown in the specification.—*June* 30, 1954.

CIVIL ENGINEERING

711,449. August 5, 1952.—REINFORCED CONCRETE CONSTRUCTIONS, Stressteel Corporation, 211, East Thirty-seventh Street, New York, U.S.A. (*Inventor: Curzon Dobell.*)

The invention relates to concrete constructions in which the incorporated reinforcement has joints or unions, and is under permanent tension, thus



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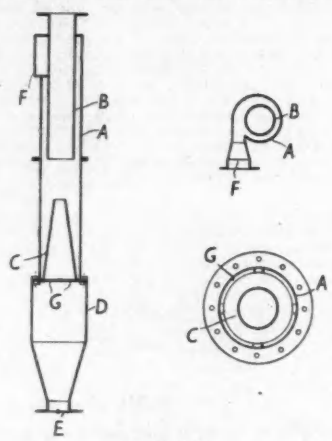
placing the concrete under permanent compression. The beam *A* shown in the drawing is made of highly dense concrete, in which there is one or more longitudinal composite reinforcing rods *B*. The composite rod *B* consists of three shorter rods *C*, *D* and *E*, joined together by turnbuckles *F* and *G*, and the whole assembly is placed under tension by the nuts *H* and *J* at the ends of the beam. In construction the reinforcing bars are first put into the mould and the concrete pressed around them, the nuts being tightened when the concrete has set. To prevent the concrete from bonding on to the rods and turnbuckles, the turnbuckles are housed in a small box *M* and are spaced by a pair of springs *N*. The remainder of the rod is covered with asphalt or tar to prevent

bonding. By means of a hydraulic jack the rod or rods are placed under a stress of from 80,000 lb to 100,000 lb per square inch and the nuts are tightened to retain this stress. Various alternative designs and uses of such composite reinforcing rods are shown in the specification.—*June* 30, 1954.

DUST EXTRACTORS

711,394. February 1, 1952.—CENTRIFUGAL DUST EXTRACTORS, Controlled Heat and Air, Ltd., Cornwall Road, Smethwick, Birmingham. (*Inventor: Charles George McKeown.*)

As the drawing shows, there is provided a vertically-disposed cylindrical casing *A* within the upper half of which is a concentric cylindrical outlet tube *B* of smaller diameter, the annular space between the casing and the outlet being closed at its upper end.



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In the lower half of this cylindrical casing is a frustum of a hollow cone *C* open at the top and bottom, the base of the cone being of slightly smaller diameter than that of the interior of the cylindrical casing *A*, and the diameter of the top of the cone being approximately a quarter of that of the outlet tube. The uppermost point of this cone *C* is spaced from the lower extremity of the outlet tube *B*, which extends down into the casing to approximately the midway position. Connected to the lower end of the casing is a cylindrical dust receiving hopper *D* of larger diameter than the casing, and having an outlet at its lower end sealed by a valve *E*. In operation, the dust-laden gas enters through a tangential inlet *F* at the upper end of the casing and descends in a spiral path through the annular space between the casing *A* and the outlet tube *B*. By virtue of the position of the frustum of the hollow cone *C* in the lower half of the casing, the speed of rotation of the gas is maintained substantially throughout the height of the casing, thereby maintaining the centrifugal action on the dust particles. Further, the taper of the cone *C* assists, controls and limits the formation of the inner upward vortex caused by the discharge of gas through the outlet tube *B*. In practice it has been found that the inner vortex starts forming when the dust-laden gas enters the uniformly decreasing annulus formed between the exterior of the frustum of a cone *C* and the interior wall of the casing *A*. Thus the quantity of gas containing the dust particles uniformly decreases as it approaches the base of the cone whilst, due to the decreasing area of the annulus, the centrifugal separating force is maintained at a higher potential than the inward force of the vortex. In consequence, an efficient extraction of the dust is effected and the dust passes through the relatively small opening *G* between the base of the cone *C* and the inner wall of the casing *A* into the dust receiving hopper. Any gas entering this dust receiving hopper rejoins the main inner upward vortex by way of the internal passage through the cone.—*June* 30, 1954.

MISCELLANEOUS

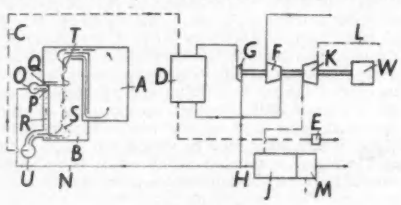
574,843. Amended. May 21, 1943.—ABRASIVE MATERIALS, Arthur Abbey, 112, Hatton Garden, London, E.C.1 (*communicated from the Carborundum Company, Niagara Falls, New York, U.S.A.*).

This invention relates to aluminous abrasive materials and particularly to fused alumina whose crystalline structure is modified by the presence of one or more other oxides that modify the alpha alumina lattice. It is an object of the invention to produce improved materials of this type by the use of modifying oxides such as those crystallising in the same general form as alpha alumina and particularly chromium sesquioxide and vanadium sesquioxide. According to this invention, an abrasive grain is produced which comprises alpha alumina containing chromium sesquioxide or vanadium sesquioxide in solid solution therein, such chromium sesquioxide being present in amount varying from 1·00 to 10 per cent of the alumina content and the vanadium sesquioxide in amount varying from 0·25 to 20 per cent of the final grain. The process for producing abrasive grain consists in sintering or fusing a raw batch containing alumina with vanadium and/or chromium oxides or other compounds thereof under conditions which form a solid solution of Cr_2O_3 and/or V_2O_3 with the alpha alumina without reduction of those oxides, and crushing the resulting mass. It is found that by modifying the alumina with chromium sesquioxide, vanadium sesquioxide or both the resulting change in crystal structure furnishes a means for greatly varying the physical properties of crystalline alumina abrasive grain. By this method a grain of increased hardness and toughness is produced. In the specification a complete description of the process is given.—*June* 30, 1954.

GAS-MAKING PLANTS

711,271. August 18, 1950.—WASTE HEAT RECOVERY INSTALLATIONS, W. H. Allen, Sons and Co., Ltd., Queens Engineering Works, Bedford, and John Thomas Bosher Oxford and Arthur William Pope, both of the company's address.

The invention relates to installations for the utilisation of waste heat from hot waste gases. The drawing shows a waste heat utilisation installation according to the invention applied to a gas-making retort of the intermittent type. The retort furnace is indicated at *A* and the recuperator at *B*, and the hot waste gases follow a path *C* to a heat exchanger or air heater *D* through which they are drawn by a fan *E* on to a chimney. An axial flow or centrifugal compressor *F* draws in air and passes it under pressure through the heat exchanger *D* to a hot air turbine *G* coupled to the compressor. The exhaust from the hot air turbine is divided at *H*, a part being supplied to a waste heat boiler *J* which supplies steam at medium pressure to drive a steam turbine *K*. Preferably a pass-out or back-pressure turbine is employed, and the extracted steam, which is at relatively low pressure, is led by a pipe *L* to process or other work. The boiler *J* is preferably provided with an economiser *M* and the waste air is led to a chimney. The other part of the turbine exhaust air, preferably the major part of the total exhaust, is returned by a line *N* for use as secondary air in the retort furnace *A* and is



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admitted to the recuperator *B*. As shown, the exhaust air is supplied to the secondary air feed main *O*, the inlet from which is controlled by dampers *P* and *Q*. With the damper *Q* closed and the damper *P* open the exhaust air will flow down a passage *R* and thence traverse the full length of the recuperator as indicated by the broken line *S*, giving normal full recuperation. By closing the damper *P* and opening the damper *Q* the exhaust air will traverse only half of the length of the recuperator as indicated by the full line *T*. In these circumstances, the retort furnace gases flow through the full length of the recuperator in the usual way, but no heat exchange takes place in the lower half. The waste gas main is shown at *U*. Owing to the fact that the secondary air *N* admitted to the recuperator is already heated, the gases leave the retort furnace at a higher temperature than in existing installations and consequently a higher temperature is available to operate the hot air turbine. The damper *P* can be opened and the recuperator supplied with unheated air if for any reason the hot air turbine should fail, thus avoiding shutting down of the retort. The amount of turbine exhaust air will always be in excess of the amount of secondary air required and a substantial proportion is accordingly available for steam raising in the boiler *J*. It is found that the amount of steam that can be raised in the boiler *J* is generally sufficient for the process requirements of the plant, but if an excess of steam is available, a pass-out and condensing steam turbine or a steam engine is employed and additional power is thus obtained. Also the steam turbine may drive an electrical generator as indicated at *W*. Other applications of this system are also given in the specification.—*June* 30, 1954.

UNDERGROUND CAR PARKS ON THE SOUTH BANK.—The General Purposes Committee of the London County Council has recommended that powers shall be sought from Parliament for the construction, maintenance, &c., of car parks under the riverside open space and to adjoining squares of the South Bank.

Technical Reports

Secondary Flow in Curved Pipes. By R. W. Detra. Zürich: Verlag Leemann, Stockerstrasse 64.—This study of the secondary flow in curved pipes was made at the Institut für Aerodynamik der Eidgenössischen Technischen Hochschule in Zürich. It includes an experimental investigation of the secondary flow phenomenon followed by a theoretical investigation of the initial or starting phases of the secondary flow in slightly bent pipes made through an application of the equations of motion of an incompressible inviscid fluid.

Structural Tests in Still Water on Welded Dry Cargo Ship "Ocean Vulcan" (Report No. R.6). Price £1 10s. *Structural Tests in Still Water on Riveted Dry Cargo Ship "Clan Alpine"* (Report No. R.7). Price £1 10s. *S.S. "Ocean Vulcan" Sea Trials: Detailed Analysis of Record No. 6 W.S (Ballast Condition)* (Report No. R.11). Price £1 7s. 6d. H.M. Stationery Office, York House, Kingsway, London, W.C.2.—The Admiralty Ship Welding Committee, in its study of the special problems arising from the use of welding in ships' structures, has carried out a programme of investigations to compare the structural behaviour of welded and riveted ships under the loadings experienced at sea. For the reasons stated in Report No. R.8 (*"Ocean Vulcan" Sea Trials: The Forces Acting on the Ship at Sea*), and in the light of the information obtained from its earlier still water structural tests, the Committee decided that the most promising approach to this problem would be to proceed with a series of trials in three stages, which are summarised:

Investigation of the stress response of two sister ships, the welded "Ocean Vulcan" (now "Cape Nelson") and the riveted "Clan Alpine" under various states of loading in still water; investigation of the loads imposed on one of these ships, the "Ocean Vulcan," under prolonged periods of sea service, and application of the results of the still water experiments to the estimation of probable maximum loads derived from the sea trials, in order to estimate the probable maximum stresses at sea for both the welded and riveted ships.

The drafts of Reports Nos. R.6, relating to the still water experiments on the "Ocean Vulcan" and R.7, relating to the static experiments on the "Clan Alpine," were prepared by Mr. K. J. Pascoe. The draft of Report No. R.11, relating to the sea trials on the "Ocean Vulcan," was prepared by Mr. F. B. Bull.

Books of Reference

Summersons Platelayers Guide. Darlington: Thomas Summerson and Sons, Ltd. Price 12s. 6d.—This guide has been widely used for many years by designers, engineers and contractors concerned with the design and layout of railway sidings. This new edition, the seventh, has been rewritten and much of the information condensed to make possible quick, easy reference, and the tables have been re-calculated to conform with modern specifications. The subject matter is arranged in sections dealing with permanent way, permanent way materials, design and development, accessories and platelaying, and it concludes with a number of useful practical tables, diagrams and formulæ.

Newnes' Engineer's Reference Book, Sixth edition. Editor, F. J. Camm. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 70s.—This well-known handbook is now available in a fully revised and expanded edition, and should be of use to anyone engaged in mechanical, civil, automobile or aeronautical engineering. The subject matter is divided into about one hundred sections including the following: mechanics, workshop mathematics, stress formulæ, strength of materials, drawing-office practice, patents designs and trade marks, bearings, gauge and screw thread measurements, surface finish measurement, spring formulæ and nomograms, grinding, lathe work, metallurgy, heat treatment, welding, compressed air, production control, quality control, time and motion study, works cost accounts, internal combustion engines, aeronautical engineering, steam engineering, heating and ventilation, plastics, electrical data. The new sections contain information on "V" belts, Unified screw threads, standard jig bushes and transformer and choke formulæ; extensive metric tables have been added. There is an excellent index with full cross-references.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB

Fri. to Mon., Sept. 24th to 27th.—Church House, Westminster, London, S.W.1, 29th Annual Conference.